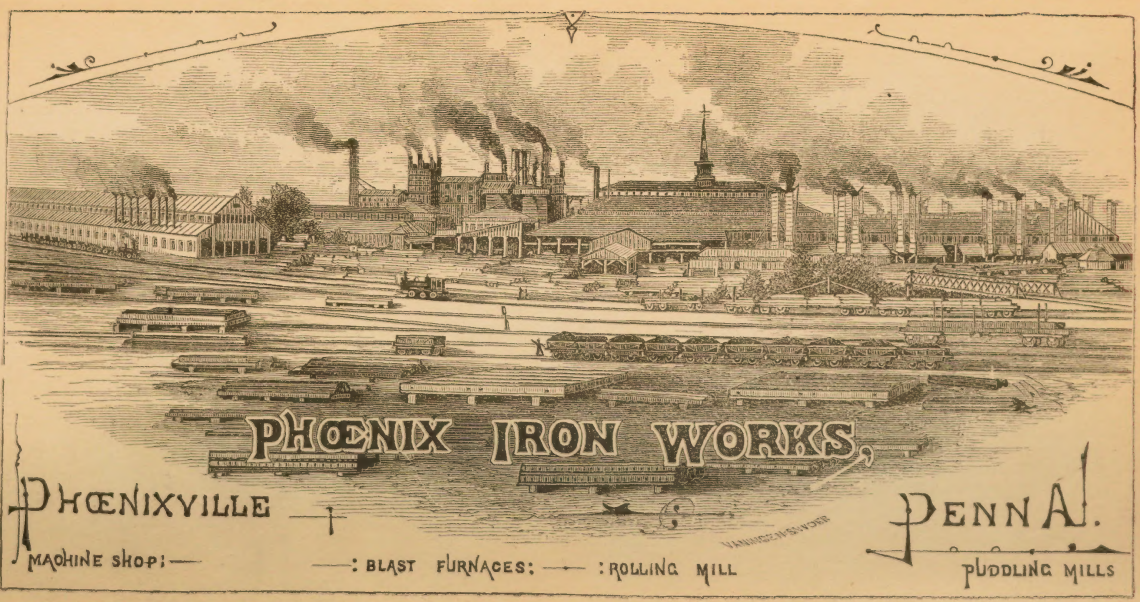
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USEFUL INFORMATION

FOR

ARCHITECTS,

ENGINEERS,

AND

Workers in Wrought Iron,

BY THE

PHŒNIX IRON COMPANY.

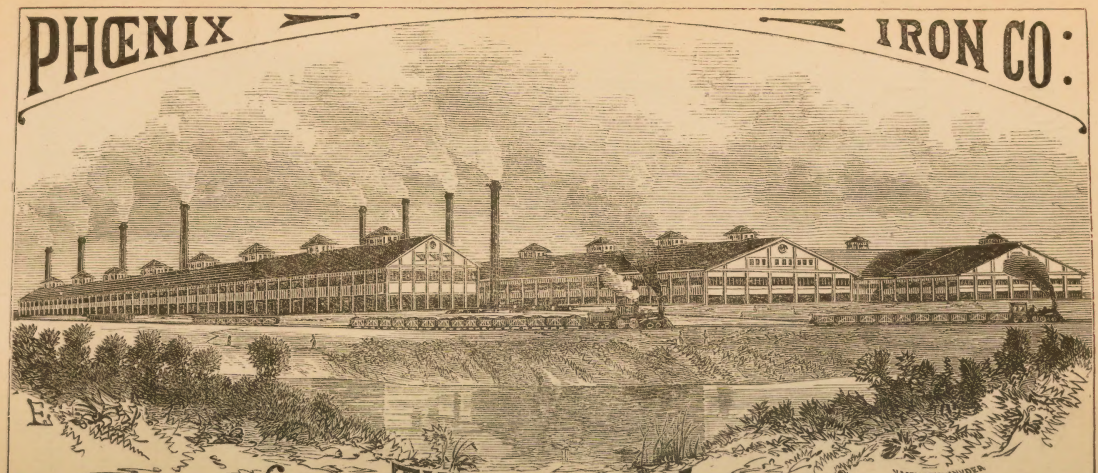
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Office, No. 410 Walnut Street,

PHILADELPHIA.

Works, Phœnixville, Pa.

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THE NEW MILL

LENGTH 930 FEET

FRONT 430 FEET

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Phœnix Iron Company,

410 WALNUT ST., PHILADELPHIA,

MANUFACTURERS OF

Wrought Iron Roof Trusses,

EITHER CURVED, STRAIGHT OR HIPPED.

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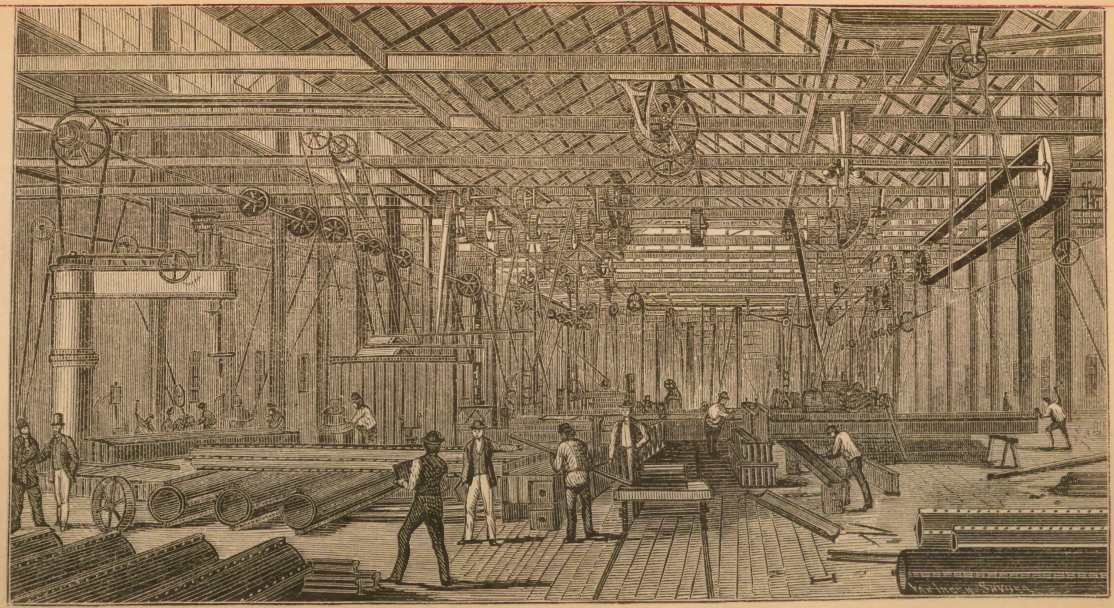
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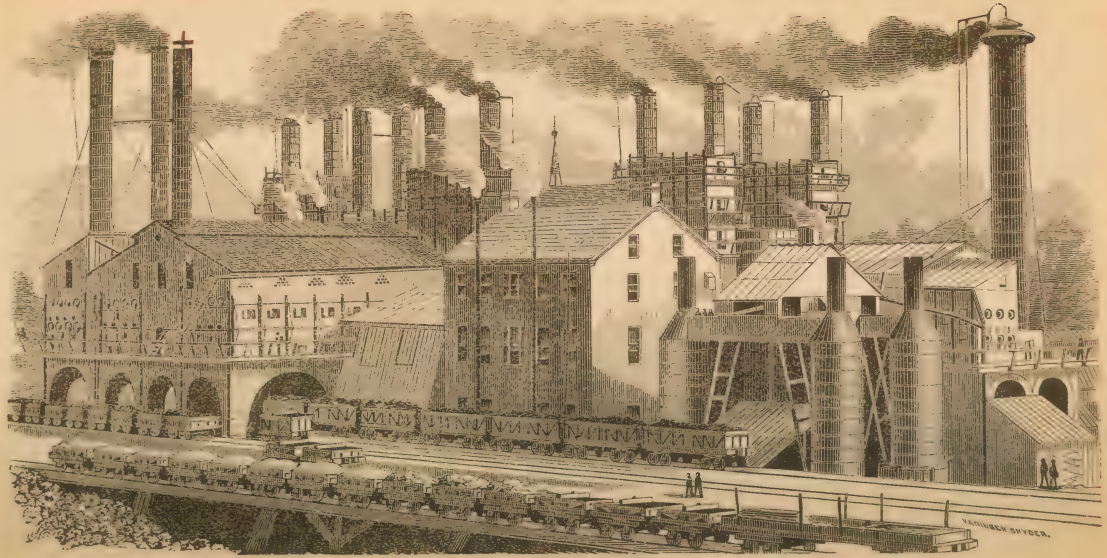
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Correspondents will please address

PHŒNIX IRON COMPANY,

410 Walnut Street,

PHILADELPHIA.



BLAST FURNACES.

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JAMES F. KRYDER, PRINTER, 32 S. SEVENTH ST., PHILADELPHIA.

DETAILS OF CONSTRUCTION

IN

WROUGHT IRON WORK,

BY THE

PHŒNIX IRON COMPANY.

For the convenience of Architects, Engineers and Contractors, some of the details of construction employed in wrought iron work, and the adaptations of the various shapes and combinations to their several purposes, are given in the following pages. These will be illustrated and explained under the heads into which the work is classified.

BEAMS, TEES, CHANNELS AND OTHER SHAPES of rolled iron are employed in the construction of FLOORS and ROOFS.

FLOORS are composed of main girders, either double or single; posts for their support, and joists for carrying the floor proper.

ROOFS are subdivided into rafters, trussed or curved, purlins and covering material.

FLOORS.

The first point of consideration in the construction of a floor, is to ascertain what load is to be sustained on each square foot of surface, and then to select the beam capable of supporting it with entire safety. In order to meet this condition I beams have been made of various dimensions from four inches deep and weighing eighteen pounds per yard up to fifteen inches weighing two hundred pounds per yard. In floors of small span, the lightest beam can be most economically used, but when the span is increased, deeper and heavier beams must be employed. That a beam should be strong enough to carry a load for a given span is not all that is requisite—it is equally important that it should be stiff enough. Rigidity prevents vibration, the avoidance of which is of great importance, since repeated movements in the floor may possibly result in the breaking of the brick arches which rest on the flanges of the floor beams. It is therefore advisable, where circumstances permit, to consider whether deep beams cannot be used with equal economy by placing them further apart, instead of lighter ones placed nearer together. The value of this suggestion will be perceived by reference to table I, under head of "Elements of Phœnix Beams," and comparing Beam No. 57, twelve inches deep and weighing one hundred and twenty-five pounds per yard, with Beam No. 4, nine inches deep and weighing one hundred and fifty pounds per yard, we find the former stronger than the latter in the ratio of 208 to 197, the factors varying directly as the depths; while their respective powers to resist deflection are in the proportion of 575.79 to 388.44, being inversely as the squares of their respective depths —the lighter beam being nearly 1½ times stiffer than the heavier one.

Under no circumstances should the floor beams be strained beyond the limits of their elasticity, or in other words, so strained that on the removal of the load, they will not return to their original condition without set or permanent deflection. Repeated trials of different sections of I beams made at Phœnixville, show that no permanent set takes place under a strain of fifteen thousand pounds per square inch, measured on the effective section of $(a + \frac{a'}{6})$, in which (a) represents the section of the top flange, and (a′) of the stem or web. But in order to take a full margin of safety, and to guard against the softening influence of excessive heat, in case of a fire, causing a diminution of the powers of resistance of iron, a factor of twelve thousand pounds or six net tons is taken as the maximum for computing the useful value of Phœnix beams in fire-proof buildings. On this basis the subjoined table (II) of strength has been computed for all the beams at present manufactured by this Company.

If a beam is required to sustain its load at the centre, the figures in the table must be divided by 2; if at any other point, the weight at the centre is to the weight at any other point, as the rectangle of the segments at the given point is to the square of half the span. The co-efficient of safety is placed above each beam on the table, and this divided by the clear span in feet, gives the strength of the beam for a distributed load in net tons of two thousand pounds.

The deflection corresponding to this load will be found in the next line for each beam, and the weight of the beam itself for the given length should be deducted from the safe load. For any less load uniformly distributed, the deflection will be directly proportionate to the one given in the table. The deflection should not exceed one-thirtieth of an inch per foot of clear span, and the dividing lines in table II show where this limit is passed for each beam.

DEFINITION OF TERMS USED IN FORMULA.

—:o:—

W = Equally distributed load on any beam in tons of 2,000 lbs.

L = Length of clear span, expressed in feet.

a = Area of top and bottom flange, in square inches.

a′ = Area of stem of beam, in square inches.

D = Effective depth, between centres of gravity of flanges, in feet.

d = Effective depth of beam expressed in inches.

S = Strain per square inch of effective section $\left(a + \frac{a'}{6}\right)$ in tons of 2,000 lbs.

δ = Deflection in inches at middle for a central load.

δ' = Deflection in inches at middle for a uniformly distributed load.

TABLE I.

ELEMENTS OF PHŒNIX I BEAMS.

General formula for an equally distributed load on any beam $W = \frac{8\,D\,(a + \frac{a'}{6})\,S}{L}$

Formula for deflection in inches at middle of beam under any load applied at the centre $\delta = \frac{.006\ W\ L^3}{(a + \frac{a'}{6})\ d^2}$

Formula for middle deflection in inches under same load equally distributed $\delta' = \frac{.004\ W\ L^3}{(a + \frac{a'}{6})\ d^2}$

No. of Beam.	Depth.			Area.			Size.			Weight of beam in lbs. pr yard.	Value of factor $\frac{8D(a+\frac{a'}{6})}{S=6\text{ tons.}}$	Value of factor $(a + \frac{a'}{6})\,d^2$
	Total inches.	Effective.		a of Flange.	a′ of Stem.	Sum of $a + \frac{a'}{6}$	Width of Flange.	Avg thickness of Flange.	Thickness of Stem.			
		D feet.	d inches.									
1	15	1.150	13.80	6.1425	7.715	7.428	$5\frac{5}{16}$ in.	1.156 in.	.65 in.	200	410	1414.59
89	15	1.170	14.04	4.330	6.340	5.386	$4\frac{3}{4}$	.911	.50	150	302	1061.69
55	12	.910	10.92	5.777	5.446	6.684	$5\frac{1}{2}$	1.050	.59	170	292	797.07
57	12	.930	11.16	3.810	4.880	4.623	$4\frac{3}{4}$	.802	.49	125	208	575.79
58	$10\frac{1}{2}$	.812	9.74	3.3535	3.793	3.986	$4\frac{1}{2}$	.745	.44	105	155	378.15
4	9	.658	7.90	5.586	3.828	6.224	$5\frac{3}{8}$	1.039	.60	150	197	388.44
5	9	.691	8.30	2.800	2.800	3.261	4	.700	.40	84	108	225.00
6	9	.698	8.38	2.381	2.238	2.754	$3\frac{1}{2}$	.680	.31	70	92	193.38
59	8	.618	7.42	2.109	2.282	2.489	4	.527	.35	65	74	137.04
7	7	.537	6.44	1.775	1.949	2.100	$3\frac{1}{2}$	.507	.35	55	54	87.09
8	6	.458	5.50	1.421	1.158	1.614	$2\frac{3}{4}$	.517	.25	40	35	48.82
106	5	.383	4.60	1.200	1.200	1.400	3	.400	.30	36	25	29.62
105	5	.385	4.62	1.000	1.000	1.166	$2\frac{3}{4}$	.375	.25	30	21	24.94
65	4	.298	3.58	1.135	.730	1.257	$2\frac{3}{4}$	.410	.25	30	18	16.11
100	4	.304	3.65	.562	.6825	.676	2	.281	.21	18	10	9.00

COMPARATIVE STRENGTH AND STIFFNESS

OF THE

Different Sections of Wrought Iron Beams

MADE BY THE

PHŒNIX IRON COMPANY,

For Sustaining, with entire safety, a Uniformly Distributed Load.

TABLE II.

No. of Beam.	1			89			55		
Size.	15″			15″			12″		
Weight per Yard.	200 Lbs.			150 Lbs.			170 Lbs.		
Load Factor.	$W=\frac{410}{L}$			$W=\frac{302}{L}$			$W=\frac{292}{L}$		
Deflection Factor.	$\delta'=\frac{.004\ W\ L^3}{1414.59}$			$\delta'=\frac{.004\ W\ L^3}{1061.69}$			$\delta'=\frac{.004\ W\ L^3}{797.07}$		
L Distance between Bearings in feet.	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*
		″			″			″	
10	41.0	.116	667	30.2	.114	500	29.2	.147	567
11	37.2	.140	733	27.4	.138	550	26.6	.177	623
12	34.2	.167	800	25.2	.154	600	24.3	.210	680
13	31.6	.196	867	23.2	.182	650	22.4	.246	737
14	29.3	.227	933	21.6	.212	700	20.9	.286	793
15	27.4	.261	1000	20.0	.254	750	19.4	.328	850
16	25.6	.296	1067	18.9	.289	800	18.3	.374	907
17	24.1	.334	1133	17.8	.327	850	17.2	.423	963
18	22.8	.376	1200	16.8	.367	900	16.2	475	1020
19	21.6	.419	1267	15.9	.410	950	15.4	.530	1077
20	20.5	.463	1333	15.1	.455	1000	14.6	.587	1133
21	19.5	.510	1400	14.4	.502	1050	13 9	.648	1190
22	18.6	.560	1467	13.7	.551	1100	13.3	.711	1247
23	17.8	.612	1533	13.1	.602	1150	12.7	.777	1303
24	17.1	.667	1600	12.6	.656	1200	12.2	.846	1360
25	16.4	.725	1667	12.1	.712	1250	11.7	.918	1417
26	15.8	.785	1733	11.6	.769	1300	11.2	.992	1473
27	15.2	846	1800	11.2	.828	1350	10.8	1.068	1530
28	14.6	.906	1867	10.8	.889	1400	10.4	1.147	1587
29	14.1	.972	1933	10.4	.942	1450	10.0	1.230	1643
30	13.7	1.04	2000	10.0	1.017	1500	9.7	1.314	1700

COMPARATIVE STRENGTH AND STIFFNESS

OF THE

Different Sections of Wrought Iron Beams

MADE BY THE

PHŒNIX IRON COMPANY,

For Sustaining, with entire safety, a Uniformly Distributed Load.

TABLE II.

57 — 12″ — 125 Lbs. — $W=\frac{208}{L}$ — $\delta'=\frac{.004\ W\ L^3}{575.79}$			58 — 10½″ — 105 Lbs. — $W=\frac{155}{L}$ — $\delta'=\frac{.004\ W\ L^3}{378.51}$			4 — 9″ — 150 Lbs. — $W=\frac{197}{L}$ — $\delta'=\frac{.004\ W\ L^3}{388.44}$			5 — 9″ — 84 Lbs. — $W=\frac{108}{L}$ — $\delta'=\frac{.004\ W\ L^3}{225.0}$		
Safe Load, Net Tons.	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*
	″			″			″			″	
20.8	.144	417	15.5	.164	350	19.7	.203	500	10.8	.192	280
18.8	.174	458	14.0	.197	385	17.8	.248	550	9.8	.231	308
17.3	.207	500	12.9	.236	420	16.4	.296	600	9.0	.276	336
16.0	.243	542	11.8	.278	455	15.2	.347	650	8.3	.324	364
14.9	.282	583	11.1	.322	490	14.1	.402	700	7.7	.376	392
13.8	.325	625	10.2	.364	525	13.2	.459	750	7.2	.432	420
13.0	.360	667	9.7	.414	560	12.3	.530	800	6.7	.488	448
12.2	.408	708	9.1	.470	595	11.6	.585	850	6.3	.550	476
11.5	.459	750	8.6	.528	630	10.9	.654	900	6.0	.622	504
10.9	.513	792	8.1	.589	665	10.3	.737	950	5.7	.695	532
10.4	.578	833	7.7	.652	700	9.8	.807	1000	5.4	.768	560
9.9	.636	875	7.3	.719	735	9.3	.891	1050	5.1	.839	588
9.4	.698	917	7.0	.788	770	8.9	.980	1100	4.9	.927	616
9.0	.763	958	6.7	.862	805	8.5	1.07	1150	4.7	1.01	644
8.7	.832	1000	6.5	.941	840	8.2	1.17	1200	4.5	1.10	672
8.3	.903	1042	6.2	1.025	875	7.9	1.27	1250	4.3	1.19	700
8.0	.977	1083	5.9	1.105	910	7.6	1.38	1300	4.1	1.27	728
7.7	1.053	1125	5.7	1.187	945	7.3	1.48	1350	3.9	1.36	756
7.4	1.131	1167	5.5	1.271	980	7.0	1.59	1400	3.8	1.48	784
7.1	1.211	1208	5.3	1.360	1015	6.8	1.70	1450	3.7	1.60	812
6.9	1.294	1250	5.1	1.455	1050	6.6	1.83	1500	3.6	1.73	840

COMPARATIVE STRENGTH AND STIFFNESS

OF THE

Different Sections of Wrought Iron Beams

MADE BY THE

PHŒNIX IRON COMPANY,

For Sustaining, with entire safety, a Uniformly Distributed Load.

TABLE II.

No. of Beam.	6			59			7		
Size.	9″			8″			7″		
Weight per Yard.	70 Lbs.			65 Lbs.			55 Lbs.		
Load Factor.	$W=\frac{92}{L}$			$W=\frac{74}{L}$			$W=\frac{54}{L}$		
Deflection Factor.	$\delta'=\frac{.004\ W\ L^3}{193.38}$			$\delta'=\frac{.004\ W\ L^3}{137.04}$			$\delta'=\frac{.004\ W\ L^3}{87.09}$		
L Distance between Bearings in feet.	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*
		″			″			″	
10	9.2	.190	233	7.4	.215	216	5.4	.248	183
11	8.4	.231	256	6.8	.264	238	4.8	.293	201
12	7.7	.275	280	6.2	.312	260	4.5	.357	220
13	7.0	.318	303	5.7	.365	282	4.2	.423	238
14	6.7	.380	326	5.3	.424	303	3.9	.491	256
15	6.2	.432	350	4.9	.475	325	3.6	.558	275
16	5.7	.448	373	4.6	.549	347	3.4	.651	293
17	5.4	.548	396	4.3	.616	368	3.2	.722	311
18	5.1	.615	420	4.1	.697	390	3.0	.803	330
19	4.8	.690	443	3.9	.780	412	2.8	.882	348
20	4.6	.761	466	3.7	.863	433	2.7	.992	366
21	4.4	.842	490	3.5	.946	455	2.5	1.06	385
22	4.2	.925	513	3.4	1.05	477	2.4	1.17	403
23	4.0	1.01	536	3.2	1.13	498	2.3	1.28	421
24	3.8	1.08	560	3.1	1.25	520	2.2	1.39	440
25	3.6	1.16	583	2.9	1.32	542	2.1	1.50	458
26	3.5	1.27	606	2.8	1.43	563	2.1	1.69	476
27	3.4	1.38	630	2.7	1.55	585	2.0	1.80	495
28	3.3	1.49	653	2.6	1.66	607	1.9	1.90	513
29	3.2	1.60	676	2.5	1.77	628	1.8	2.01	531
30	3.1	1.73	700	2.4	1.88	650	1.8	2.23	550

COMPARATIVE STRENGTH AND STIFFNESS

OF THE

Different Sections of Wrought Iron Beams

MADE BY THE

PHŒNIX IRON COMPANY,

For Sustaining, with entire safety, a Uniformly Distributed Load.

TABLE II.

8 6″ 40 Lbs. $W=\frac{35}{L}$ $\delta'=\frac{.004\ W\ L^3}{48.82}$			106 5″ 36 Lbs. $W=\frac{25}{L}$ $\delta'=\frac{.004\ W\ L^3}{29.62}$			105 5″ 30 Lbs. $W=\frac{21}{L}$ $\delta'=\frac{.004\ W\ L^3}{24.94}$			65 4″ 30 Lbs. $W=\frac{18}{L}$ $\delta'=\frac{.004\ W\ L^3}{16.11}$		
Safe Load, Net Tons.	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*	*Safe Load, Net Tons.*	*Corresponding Deflection.*	*Wt. of Beam in Lbs.*
	″			″			″			″	
3.5	.286	133	2.5	.337	120	2.1	.336	100	1.80	.448	100
3.2	.348	146	2.3	.413	132	1.9	.405	110	1.63	.545	110
2.9	.410	160	2.0	.466	144	1.7	.471	120	1.50	.643	120
2.7	.486	173	1.9	.563	156	1.6	.563	130	1.38	.752	130
2.5	.562	186	1.8	.667	168	1.5	.660	140	1.28	.872	140
2.3	.636	200	1.7	.774	180	1.4	.757	150	1.20	1.00	150
2.2	.738	213	1.6	.885	192	1.3	.854	160	1.12	1.13	160
2.0	.805	226	1.5	.995	204	1.2	.945	170	1.06	1.29	170
1.9	.907	240	1.4	1.10	216	1.2	1.12	180	1.00	1.44	180
1.8	1.01	253	1.3	1.20	228	1.1	1.21	190	.95	1.62	190
1.7	1.11	266	1.2	1.29	240	1.0	1.28	200	.90	1.79	200
1.6	1.21	280	1.2	1.50	252	1.0	1.45	210	.85	1.95	210
1.6	1.39	293	1.1	1.58	264	.95	1.62	220	.81	2.14	220
1.5	1.49	306	1.1	1.80	276	.90	1.75	230	.78	2.35	230
1.5	1.58	320	1.0	1.86	288	.85	1.88	240	.75	2.57	240
1.4	1.79	333	1.0	2.11	300	.82	2.05	250	.72	2.79	250
1.3	1.87	346	.95	2.25	312	.80	2.25	260	.69	3.01	260
1.3	2.09	360	.92	2.44	324	.77	2.43	270	.66	3.26	270
1.2	2.15	373	.90	2.66	336	.75	2.64	280	.64	3.51	280
1.2	2.39	386	.86	2.83	348	.72	2.81	290	.62	3.77	290
1.1	2.43	400	.83	3.20	360	.70	3.03	300	.60	4.02	300

TABLE III.

To *find the distance from centre to centre,* to place beams, when the length between supports, and the entire load per square foot of floor, are given: The total load for each beam will be represented by W = PLB, in which P = load in lbs. on each superficial square foot; L = clear span; B = distance between centres of parallel beams.

In equation $W = \frac{8\,D\,(a + \frac{a'}{6})\,S}{L}$, substitute value of W, as above. Then $PLB = \frac{8\,D\,(a + \frac{a'}{6})\,S}{L}$; and $B = \frac{8\,D\,(a + \frac{a'}{6})\,S}{PL^2}$

If P = 140 lbs. per sq. foot, and S = 6 tons or 12,000 lbs. per sq. inch strain on effective sectional area of any beam, then this table will give the proper distances apart for placing each size beam in feet and decimals of a foot.

$8D(a+\frac{a'}{6})6$	= 25	= 35	= 54	= 74	= 92	= 108	= 197	= 155	= 208	= 292	= 302	= 410
	5″ 36	6″ 40	7″ 55	8″ 65	9″ 70	9″ 84	9″ 150	10½″ 105	12″ 125	12″ 170	15″ 150	15″ 200
L = feet.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.	B = ft.
10	3.57	5.00	7.70	10.60	13.00							
12	2.48	3.47	5.36	7.34	9.02	10.71						
14	....	.....	3.94	5.39	6.70	7.87	14.00	11.28	15.09			
16	.....	.....	.....	4.13	5.14	6.02	10.70	8.65	11.55	16.30	16.86	
18	.....	.....	.....	.....	4.05	4.76	8.68	6.83	9.15	12.87	13.32	18.10
20	.....	.....	.....	.....	.....	3.86	7.04	5.54	7.39	10.43	10.80	14.64
22	.....	.....	.....	.....	.....	.....	.....	4.58	6.11	8.62	9.00	12.10
24	.....	.....	.....	.....	.....	.....	.....	3.84	5.13	7.24	7.49	10.17
26	.....	.....	.....	.....	.....	.....	.....	3.28	4.38	6.17	6.40	8.66
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.50	7.48
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.80	6.51

THE PHŒNIX IRON COMPANY.

(*a*) NOTE.—If P be any other weight than 140 lbs., the corresponding value of B will be found thus: *As* any other weight P′ *is to* 140 lbs. P, *so is* the value of B in the table, *to the* required new value of B′.

1. *Example*—What will be the proper value of B for a 10½ inch beam 20 feet between supports, when P′ is 200 lbs. per square foot carried?

P′ : P :: B : B′

200 : 140 :: 5.54 : 3.88 ft.—Answer.

$$B' = \frac{PB}{P'}$$

(*b*) For any given span, and when it is equally convenient to set the beams apart at the distances B, B, B, corresponding to their several sizes in the above table, *the cheapest* or *most economical beam to use, is the deepest of the series—even with the extra charges for size and length* added.

2. *Example*—For a 26 feet span, what is comparative weight of iron and cost per square foot of floor sustained, of a 10½″ 105; a 12″ 125 and a 15″ 150 beam, placed apart at their respective distances B in table.

	Iron per □′		Per lb.	Cents.	Ratio.
10½″	10.57 lbs. @		= 6 c.	= .63⁴²	= $1.00
12″	9.51 lbs. @	6¼+¼	= 6½c.	= .61⁸¹	= 97½
15″	7.81 lbs. @	6½+¼+¼ = 7	c.	= .54⁶⁷	= 86¼

(*c*) The *stiffness* of a floor is greater when a suitable number of deep beams are used in preference to a greater number of shallower ones of equal strength. For any given span, to find the rigidity of a floor, ascertain from table I the bending moments of the several beams under comparison; and from table III their respective distances B for given span—and divide the former by the latter. The quotients will represent their respective ratios of stiffness in the floor.

Example.—What would be the relative stiffness of a floor of 26 feet span, supported by a 10½″ a 12″ 125 and 15″ 150 beam—set apart at their respective distances B for the given span, P being 140 lbs., and S 12,000 lbs. in each case.

From last column in table **I** find for each beam its bending moments $(a + \frac{a'}{6})\ d^2$, and in table **III** the several values of B for a span of 26 feet.

Thus, for

Ratio.

10½″ Beam, $\frac{(a + \frac{a'}{6})\ d^2}{B} = \frac{378.15}{3.28} = 115.3 : 1$

12″ Beam, $\frac{(a + \frac{a'}{6})\ d^2}{B} = \frac{571.49}{4.38} = 130.5 : 1.13\frac{1}{4}$

15″ Beam, $\frac{(a + \frac{a'}{6})\ d^2}{B} = \frac{1061.69}{6.40} = 165.8 : 1.44$

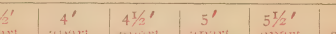
(*d*) The deflection of beams being directly as the cubes of their lengths, and inversely as the squares of their depths, and the depth of each beam being invariable for any length, the span of any beam as a floor joist is limited to a length which will give a deflection at its centre not greater than about one-thirtieth of an inch per foot of clear span. This amount of deflection is attained when the length between supports, is about 26 times the depth of the beam.

The following *lengths* for *each size beam* correspond with the above conditions under a strain S = 12,000 lbs. When the lengths exceed these limits, the load must be diminished to correspond with a diminished value for S. It is also to be understood that lateral flexure is provided against by intermediate arches or bracing.

Size of Beam,	5″	6″	7″	8″	9″ 70	9″ 84	9″ 150
Length "	11′	12′	14′	16′	18′	18′	18′
Size of Beam,	10½″	12″ 125	12″ 170	15″ 150	15″ 200		
Length "	22′	24′	24′	30′	30′		

PHŒNIX BEAMS.

THEIR ADAPTATION AND DUTY AS FLOORING JOISTS.



Clear Span	3′ apart	3½′ apart	4′ apart	4½′ apart	5′ apart	5½′ apart	6′ apart
10 feet	30 □′	35□′	40 □′	45 □′	50 □′	55 □′	60 □′
Load lbs	4,200	4,900	5,600	6,300	7,000	7,700	8,400
I	6″				7 or 8″		
12 feet	36 □′	42	48	54	60	66	72
Load lbs	5,040	5,880	6,720	7,560	8,400	9,240	10,080
I	6 or 7″		7″		8″		
14 feet	42 □′	49	56	63	70	77	84
Load lbs	5,880	6,860	7,840	8,820	9,800	10,780	11,760
I	7 or 8″		8 or 9″ 70			9″ 70	
16 feet	48 □′	56	64	72	80	88	96
Load lbs	6,720	7,840	8,960	10,080	11,200	12,320	13,440
I	8″		9″ 70	9″ 84		10½″ 105	
18 feet	54 □′	63	72	81	90	99	108
Load lbs	7,560	8,820	10,080	11,340	12,600	13,860	15,120
I	8 or 9″ 70	9″ 84		10½″ 105			
20 feet	60 □′	70	80	90	100	110	120
Load lbs	8,400	9,800	11,200	12,600	14,000	15,400	16,800
I	9 84 or 10½	10½″ 105				12 125	
22 feet	66 □′	77	88	99	110	121	132
Load lbs	9,240	10,780	12,320	13,860	15,400	16,940	18,480
I	10½″ 105			12″ 125			12″ 170
24 feet	72 □′	84	96	108	120	132	144
Load lbs	10,080	11,760	13,440	15,120	16,800	18,480	20,160
I	10½ or 12″ 125		12″ 125		12 170 or 15″ 150		
26 feet	78 □′	91	104	117	130	143	156
Load lbs	10,928	12,740	14,560	16,380	18,240	20,020	21,840
I	10½ or 12	12″ 125		12 170 or 15″ 150			15″ 150
28 feet	84 □′	98	112	126	140	154	168
Load lbs	11,760	13,720	15,680	17,640	19,600	21,560	23,520
I	12 125 or 15″ 150		12 170 or 15″ 150		15″ 150	15″ 200	
30 feet	90 □′	105	120	135	150	165	180
Load lbs	12,600	14,700	16,800	18,900	21,000	23,100	25,200
I	12 or 15 150	12 170 or 15″ 150		15″ 156	15″ 200		

In above table the load is taken at 140 lbs. per □ foot of floor.

BEAMS are generally laid in floors as shown in Fig. 1, the joists either resting on top of the girders, as in Fig. 2, or bolted to the sides of the girders.

Fig. 3 shows the detail of connection when the under sides are made flush, Fig. 4 the joint to bring the upper sides flush, and Fig. 5 shows the form usually adopted when the beams are of the same size or the centre lines are brought together. Arrangements of this kind are also used to connect the trimmer beams of hatchways, jambs and stairways. Fig. 6 shows the end of a double girder resting on a cast shoe plate, the beams being joined with a cast separator and bolts.

The wall end of the joists should also be provided with a *shoe or bearing* plate of iron or stone, as the brickwork is apt to crush under the end of the beam unless the load is distributed by this means over a sufficient surface. *Anchor straps* should be bolted *to the end of each girder*, and *to the wall end* of every alternate joist, binding the walls firmly from falling outwards in the event of fire or other accident.

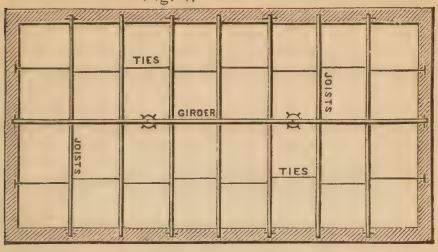
Several simple modes of anchorage are shown in Figs. 3, 4 and 5.

When one beam does not give sufficient strength for a girder it is customary to bolt together two or more with cast separators between them. Figs. 6 and 7. For carrying a wall nine inches thick, two beams laid close together, of depths proportioned to the span; and for thirteen inch walls the same beams, with a space between them, make a very good arrangement, care being taken to bind the two beams firmly together with separators and bolts every six or eight feet.

When the length of the span becomes too great for the girder, and posts are introduced for intermediate supports, joint boxes of simple pattern are provided at each floor, forming caps and bases for the wrought iron columns and at the same time serving to unite the girders continuously through the length of the building.

The cap or base may be of any ornamental pattern desired to give a finish to the column.

Fig. 1.



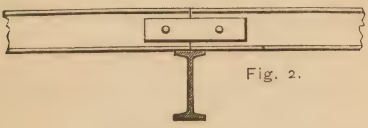


Fig. 2.

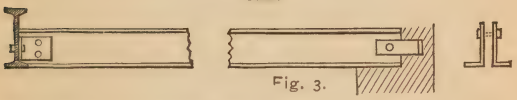


Fig. 3.

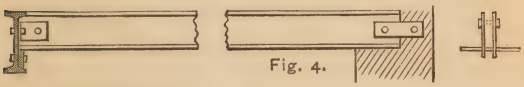


Fig. 4.

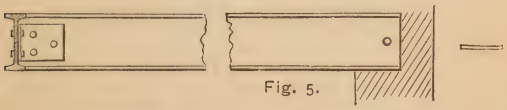


Fig. 5.

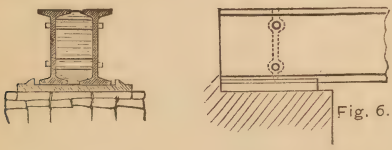


Fig. 6.

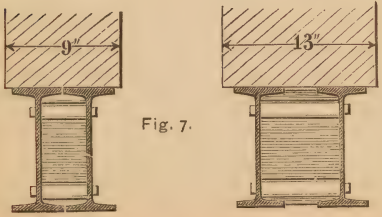


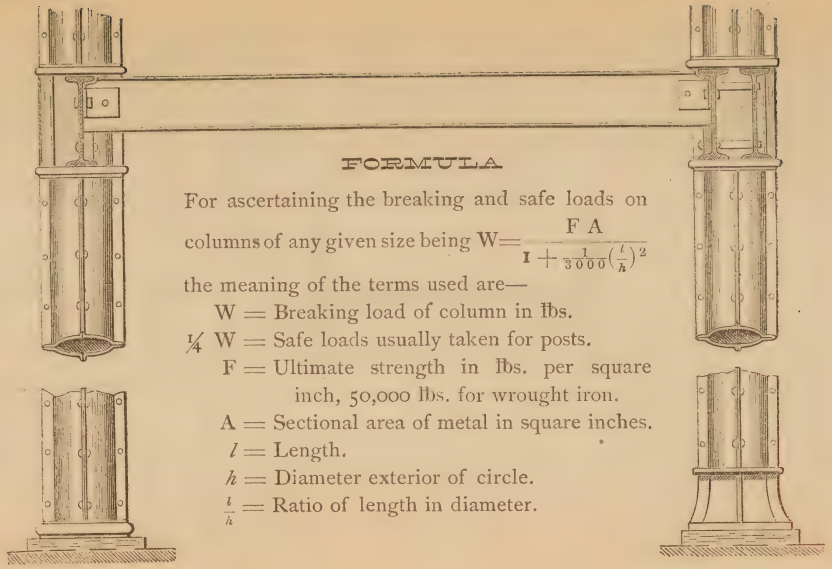
Fig. 7.

COLUMNS varying in size from the small 4 segment A, 3⅝ inches inside diameter, and capable of supporting a load of 7¾ tons with safety when 20 feet long, to the massive 8 segment tube G, 14⅜ inches inside diameter, with strength sufficient to bear safely 460 tons when of the same length, can be selected from the table given below:

TABLE OF SIZES
PHŒNIX
PATENT WROUGHT IRON COLUMNS.

Mark of Column.	One Segment.		One Column.		Internal Diameter of Column in Inches.
	Thickness in Inches.	Weight in Lbs. Per Yard.	Area in Square Inches.	Weight in Lbs. Per Foot.	
A 4 Seg.	1/8 5/16	7 14½	2.8 5.8	9.3 19.3	3⅝
B¹ 4 Seg.	3/16 ⅜	12½ 37	5.0 14.8	16.6 49.3	4 13/16
B² 4 Seg.	3/16 ⅜	14½ 42½	5.8 17.0	19.3 56.6	5 15/16
C 4 Seg.	3/16 1 3/16	22 100	8.8 40.0	29.3 133.3	7 3/16
D 5 Seg.	¼ ⅜	28 52	14.0 26.0	46.6 86.6	9⅛
E 6 Seg.	¼ 1 3/16	28 100	16.0 60.0	53.3 200.0	11
F 7 Seg.	⅜ ⅜	35 52	24.5 36.4	81.6 121.3	13
G 8 Seg.	5/16 1 3/16	30 100	24.0 80.0	80.0 266.6	14⅜

NOTE.—The weight of rivet heads will add about 3½ per cent. to the net weight of columns.



FORMULA

For ascertaining the breaking and safe loads on columns of any given size being $W = \frac{F\,A}{1 + \frac{1}{3000}\left(\frac{l}{h}\right)^2}$

the meaning of the terms used are—

W = Breaking load of column in lbs.

¼ W = Safe loads usually taken for posts.

F = Ultimate strength in lbs. per square inch, 50,000 lbs. for wrought iron.

A = Sectional area of metal in square inches.

l = Length.

h = Diameter exterior of circle.

$\frac{l}{h}$ = Ratio of length in diameter.

410 WALNUT ST., PHILADELPHIA.

Cases frequently occur in which a column cannot be introduced into the building, and the girder must then be deepened and made strong enough to bear its load without such assistance. For this purpose girders are built of plate and angle irons combined in suitable form to resist the strains induced by the load in the several members, and of depths that vary to suit the special conditions of each case.

Fig. 8 shows the usual form adopted for plate girders. The ends should be further stiffened by vertical members, to resist the shearing strain on the web at the points of support, as shown on opposite page.



Fig. 8.

Box Girders (as below) composed of a combination of plates, with beam or channel irons, are also frequently used, and may be built up in sections, varying according to architects' designs.

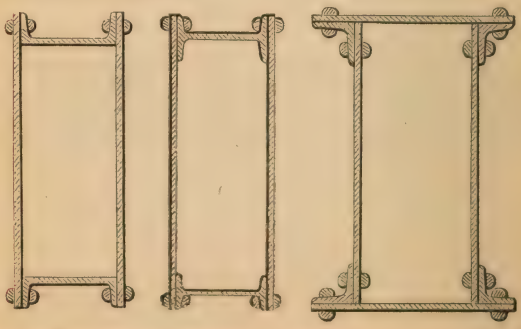
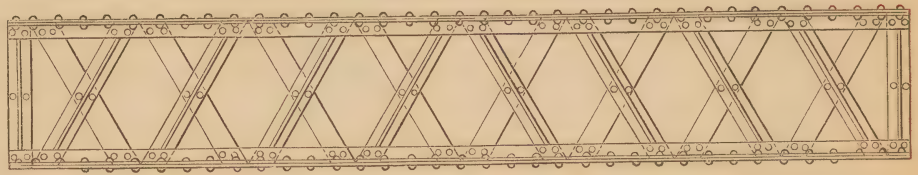






PLATE GIRDER.





LATTICE GIRDER.

Between the joists the spaces are filled up with brick arches, resting on the lower flanges against cast iron or brick skew backs.

The bricks should be moulded with a slight taper to suit the arch, and be laid in place with as little mortar as possible. Above the arch, the space is filled with grouting, in which wooden strips 2″×1″ are bedded for nailing the flooring to. The thrust of the arches is taken up by a series of tie rods, placed in lines from 6 to 8 feet apart, and usually from ¾ to 1 inch in diameter, as shown in plan (Fig. 9), that run from beam to beam, from one end of the building to the other, being anchored into each end wall with stout washers, an angle bar or channel serving as a wall plate for distributing the strain produced by the thrust of the first arch.

Instead of the brick arches corrugated iron is sometimes used to fill in the spaces. It is placed on the lower flanges of the beams and filled in above with cement in place of brickwork.

The centres for turning the arches can be suspended by iron straps hooked on the lower flange, and detachable on one side so that the frames can be shifted from point to point as the work progresses. If a flush surface is preferred for the ceiling, it may be obtained by wedging strips of pine between the beams, and tacking the laths diagonally to the under side of these, finishing with a smooth and fair surface of plastering, and thus entirely concealing the iron work above. Hollow brick moulded especially for this class of work have been used to some extent in the place of solid arching, with the object of diminishing the dead weight. The cost, however, is somewhat greater than solid bricks. Latterly, also, what are called flat arches, made of hollow bricks, have been introduced, the object being to secure a flat ceiling; but as this device, however called, is not an arch, the advantage proposed in its use cannot compensate for its defect in strength.

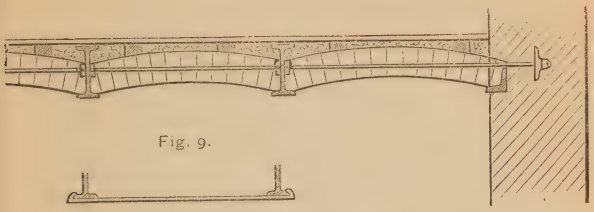


Fig. 9.

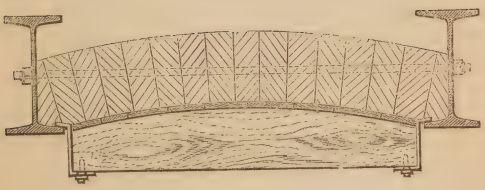
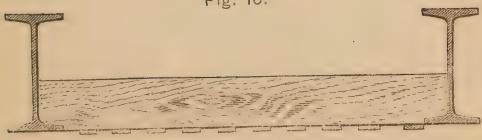


Fig. 10.



ROOFS.

Iron trusses for rafters have been rapidly growing into favor with architects of late, owing in large measure to the combined lightness, strength, durability, and consequent economy of such structures. Various forms have been proposed for the trusses, some of the best known of which are here shown.

Figs. 11 and 15 are familiar illustrations. Fig. 12 shows the modification of the ordinary King and Queen truss as adapted to wrought iron, and Figs. 13 and 14 give examples of arched trusses that have been employed to cover depots and market houses when a pleasing shape has been sought for the general outline of the building. For simplicity and economic arrangement of material, the design exhibited in Figs. 11 and 15 offers advantages over either of the other forms, and is most generally adopted in practice.

For the principals  or  beams make very good rafters, and in light trusses  bars, or two channel bars  either with or without a plate riveted to the upper flanges, answer every purpose. Struts may be made of light columns  A or B, of  bars, or of angle iron  any of these forms affording great facility for attachment to the rafters.

For arched roofed trusses the details of construction are very similar to those described for peaked roofs; but as they are capable of great variety of treatment, the best illustrations that can be given of their forms will be by referring to Figs. 13 and 14—the highly ornamental and substantial roofs constructed by the Phœnix Iron Company for the market-house corner of Twelfth and Market streets, Philadelphia, and for the station-shed at Altoona, on the Pennsylvania Railroad. These instances show the wide range of which the subject is susceptible.

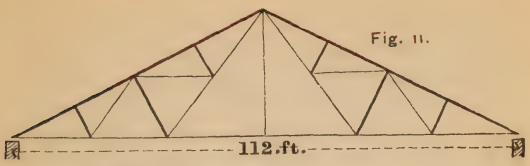


Fig. 11.

NEW MILL
PHŒNIX IRON WORKS. ROCK ISLAND ARSENAL.

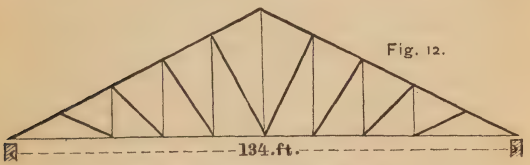


Fig. 12.

MASONIC TEMPLE, Philadelphia.

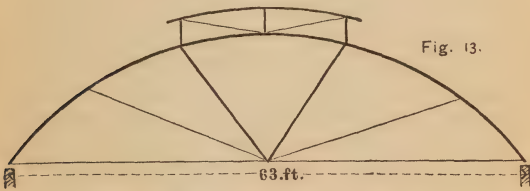


Fig. 13.

MARKET HOUSE, 12th and Market Sts., Philada.

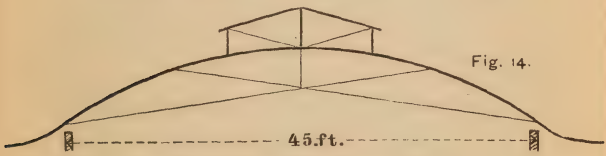


Fig. 14.

ALTOONA STATION, Penna. R.R.

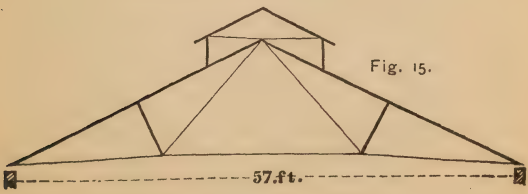


Fig. 15.

LEBANON FURNACE.

TIES may be of flat or round bars, attached by eyes and pins or screw ends. Care should be especially taken to properly proportion the dimensions of eyes and pins to the strains upon them. A very good and safe rule in practice is to make the diameter of the pin *from ¾ to ⅞ of the width of the bar in flats* and 1¼ *times the diameter of the bar in rounds*, giving the eye a sectional area of 50 per cent. in excess of that of the bar. The *thickness* of *flat bars* should be at least *one-fourth of the width in order* to secure good bearing surface on the pin, and the metal at the eyes should be as thick as the bars on which they are upset. Eyes are forged on the ends of flat or round bars by hydraulic pressure in suitably shaped dies, and, while the risk of a welded eye is thus avoided, a solid and well formed eye is made from the iron of the bar itself. A similar process is adopted for enlarging the screw ends of long rods, so that when the screw is cut, the diameter at the root of the thread is left a little larger than the body of the rod. Frequent trials with such rods has proven that they will pull apart in tension anywhere else but in the screw, the threads remaining perfect, and the nut turning freely after having been subjected to such a severe test. By this means the net section required in tension is made available with the least excess of material, and no more dead weight is put upon the structure than is actually required to carry the loads imposed.

The details of roof trusses vary to suit the character of the work and the sections of iron employed.

The heel of the rafter rests on the wall, either in a cast iron skewback fitted to the beam, and sloping to the angle required by the pitch of the roof, or between a couple of wrought angle brackets riveted to the end of the rafter and resting on a wall-plate anchored to the wall. The struts are attached to the rafters by cast caps or by wrought strap plates, and the joint at their feet is easily made either for pin or screw connections. The peak is joined by wrought plates and bolts, the beams having been cut to the required angle.

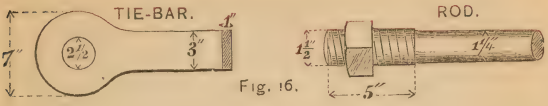


Fig. 16.



Fig. 17.
HEELS.

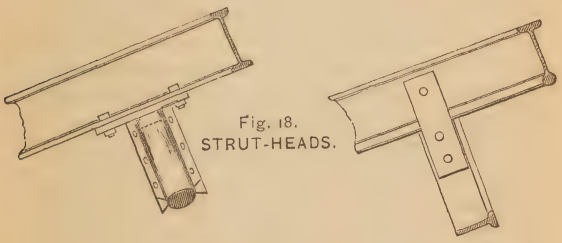


Fig. 18.
STRUT-HEADS.

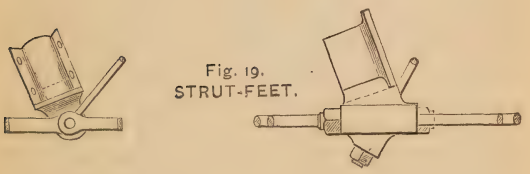


Fig. 19.
STRUT-FEET.

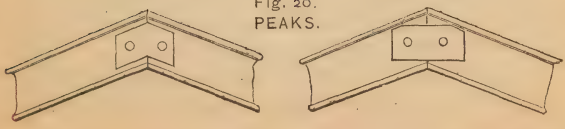


Fig. 20.
PEAKS.

Main rafters may be spaced from four to twenty feet apart, the spacing being regulated by the size of the purlin, and this again by the material used for covering. For slate on iron purlins a convenient spacing is about eight feet between centres of rafters, the angle iron purlins being put at seven to fourteen inches apart, according to the size of the slate used, and notched at the ends into the flanges of the rafters. They are held in place by tie rods that reach from rafter to rafter the entire length of the building, three or four rows of these rods being placed between peak and heel, at from six to eight feet intervals. On the iron purlins the slate may be laid directly and held down by copper or lead nails, clinched around the angle bar, as shown in Fig. 21; or a netting of wire may be fastened to the purlins, and a layer of mortar spread on this, in which the slates are bedded. When greater intervals are used in spacing rafters, the purlins may be light beams fastened on top or against the sides of the principals with brackets, allowance always being made for longitudinal expansion of the iron by changes of temperature. On these purlins are fastened wooden jack rafters carrying the sheathing boards or laths, on which the metallic or slate covering is laid, in the usual manner; or sheets of corrugated iron may be fastened from purlin to purlin, and the whole roof be entirely composed of iron.

When the rafters are spaced at such intervals as to cause too much deflection in the purlins, they may be supported by a light beam, placed midway between the rafters and trussed transversely with posts and rods. These rods pass through the rafters, and have beveled washers, screws and nuts at each end for ajustment. By alternating the trusses on either side of the rafter, and slightly increasing the length of the purlins above them, leaving all others with a little play in the notches, sufficient provision will be made for any alteration of length in the roof, due to changes of temperature.

When wooden purlins are employed they may be put between the rafters and held in place by tie rods, or on

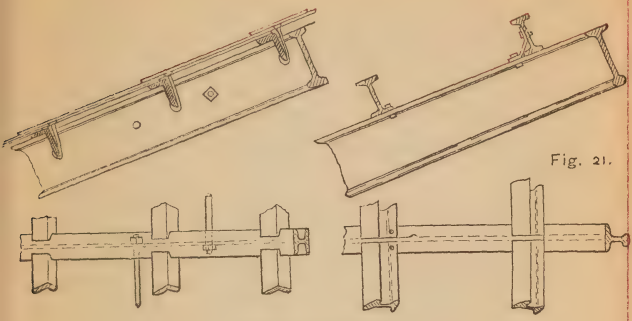
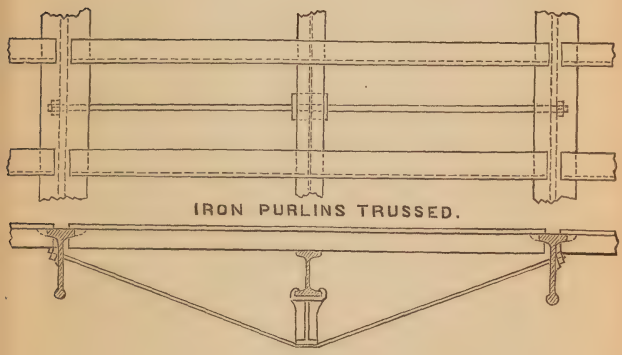


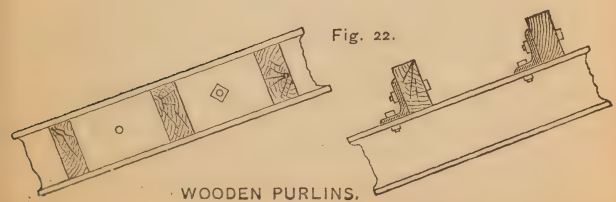
Fig. 21.

IRON PURLINS.



IRON PURLINS TRUSSED.

Fig. 22.



WOODEN PURLINS.

top and fastened to the rafter by brackets; or hook head spikes may be driven up into the purlin, the head of the spike hooking under the flange of the beam, spacing pieces of wood being laid on the top of the beam from purlin to purlin. The sheathing boards and covering are then nailed down on top of all in the usual manner.

When desired, ventilators or lanterns are added along the ridge of the roof, as seen in Fig. 15, the attachments being securely made to the rafters by wrought brackets and bolts, and the bracing effected in a cheap and thorough manner by two tie rods that run from the peak of the rafter to the angle between the post and rafter of the ventilator, the covering material being attached, as described for the main rafters.

When it becomes desirable to suspend a ceiling from the rafter, the tie-rods are replaced by a beam, and the ceiling is attached to the lower flanges, curved T bars at the cornice serving to give any ornamental finish to the interior that may suit the design of the architect.

For Mansard roofs short additional beams are allowed to project beyond the walls, and on these rest the feet of the T bar or [bar framing, well fastened by wrought brackets and bolts. On the framing are secured the $1\frac{1}{2} \times \frac{3}{8}$ inch laths for attachment of the slate or metal covering, and with a cornice of galvanized sheet iron perfect immunity from fire may be secured. This form of roof work in wrought iron admits also of great scope for ornamental design, but from the amount of work required it becomes rather more expensive than the less intricate combinations, and as no two are alike in point of detail, it is difficult to estimate the cost of construction. Curving shaping, and jointing the many pieces must be carefully done to secure the close fitting that is requisite, and practical experience in such work is of very great advantage to the builder. (The roof of the new post-office in New York is a very good illustration of the peculiarities of this class of work.)

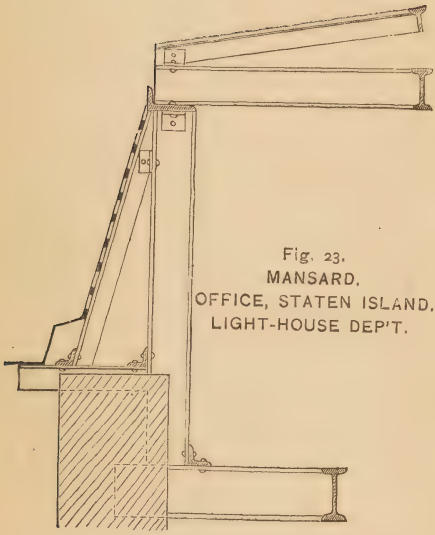


Fig. 23.
MANSARD.
OFFICE, STATEN ISLAND.
LIGHT-HOUSE DEP'T.

In Fig. 24 the purlins of angle iron carry wooden strips, to which are nailed the sheathing boards, and covering material. A netting of wire may be used to attach the plastering to the lower flanges of the tie beams or light arches of tiles or hollow bricks may be turned on the lower flanges of smaller transverse beams as described for floors.

In roofs of wide span, provision for expansion of the iron due to changes of *temperature* must be made by resting the skewback of one end of the truss on a cast wall plate with rollers interposed to permit of the sliding of the heel without straining the wall, but this precaution is not necessary in roofs of sixty feet span or less. Careful experiments have proved that an iron rod one hundred feet long will vary about $\frac{1}{10}$ of a foot for a change of temperature of 150 degrees Fahren. and as this is the greatest range to which iron beams and rods in a building would probably be subjected in this climate, compensation to that amount would be sufficient for all purposes. For sixty feet span the vibration of each wall would then be only $\frac{15}{1000}$ of a foot either way from the perpendicular, a variation so small and so gradually attained that there is no danger in imposing it upon the side walls by firmly fastening to them each heel of the rafter. Expansion is also provided against by fastening down one heel with wall bolts and allowing the other to slide to and fro on the wall-plate without rollers, as shown in Fig. 15.

In estimating the strains on roofs the weight of the structure itself as well as the loads to be supported must be taken into account. Tredgold's assumption of the total maximum vertical load at 40 pounds per square foot of horizontal surface is usually considered sufficiently high; but, if a floor or ceiling is suspended to the tie beam, or should the under side of the rafters be boarded and plastered, it is evident that these additional weights require more strength in the roof for their support.

For ordinary roofs of short span, 30 pounds per square foot is quite enough however, and for long spans over sixty feet, 35 pounds will be sufficient to provide for with the factors of safety in the material that are usually

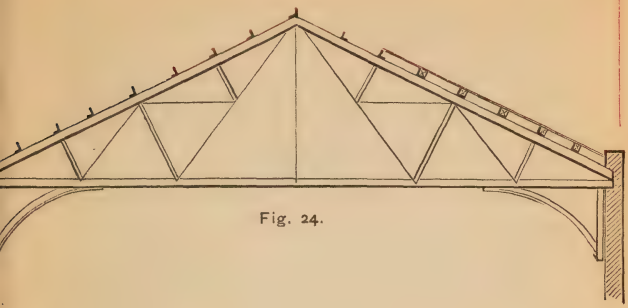
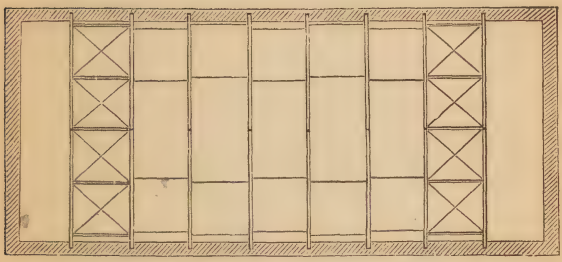


Fig. 24.



FRAMING and BRACING OF ROOF. Fig. 26.

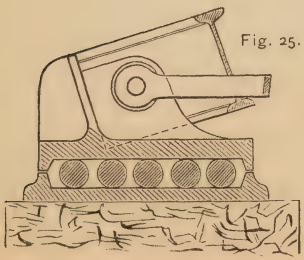


Fig. 25.

adopted. The stresses upon each member of the truss having been determined by any of the methods of calculation preferred the sectional areas may be found by taking the safe tensile strength of good wrought iron at 10,000 pounds per square inch and the compressive resistance of beam or shape iron at from 6,000 to 8,000 pounds for the same unit of section.

It should be noted that the smaller or counterbrace rods ought to be made strong enough to resist strains induced by wind pressure on one side of the roof only—the other half being unloaded.

Lateral braces, as in Fig. 26, should be provided in each end panel of straight roofs, as well to secure the roof during erection as to provide an abutment that will uphold the whole in case of fire or accident. From the panels so braced tie rods run to each of the other rafters, and, with the purlins, unite the roof into a firm and compact whole. The gable walls are sometimes used to anchor the end rods into, but the method shown in the figure is that which is generally preferred.

A very economical combination of iron rafters with wrought iron posts is shown in Fig. 27, this arrangement being well adapted for machine shops, foundries, or other buildings in which it is desirable to cover a large area and also to have an ample supply of light on the floor.

The posts on each side are placed from sixteen to twenty feet apart, and the heel of the intermediate rafter is supported by a trussed beam attached to the heads of the posts, the sheds on either side being covered by beams, trussed or untrussed, as the length of span may require. The skewback of the rafter and the cap of the post are cast in one piece, and all of the details of attachment between the parts are made in an equally simple and substantial manner. As a round-house for locomotives, or for many other purposes connected with railroad management, shops arranged on this plan commend themselves to the attention of engineers and master mechanics, and for private establishments they have been found to answer their purpose admirably well, giving the maximum of surface covered at the minimum of first cost.

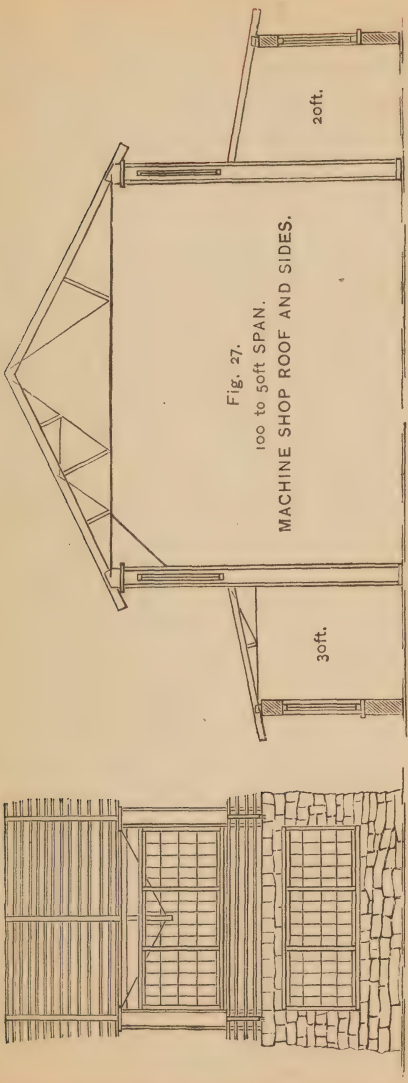


Fig. 27.
100 to 500ft SPAN.
MACHINE SHOP ROOF AND SIDES.

TEST OF BEAMS.

TRANSVERSE STRENGTH.—As trustworthy data on which to base calculations for the efficiency of beams under transverse strain the tables given below are now published; having been the result of carefully conducted experiments on the part of the Phœnix Iron Company.

From these tables have been ascertained the coefficients for the safe load of each beam, so that it will be seen that dependence has not been placed merely on theoretical formulæ in assigning these values, but the truth of these formulæ has been demonstrated by the test of actual experiment.

7 inch Beam.
60 lbs. per yd. Area 6 sq. in.
Clear Span 21 feet.

Centre load in lbs.	Deflection inches.	Increase inches.	Remarks.
2,000	.468		
3,000	.743	.275	
4,000	1.020	.277	
5,000	1.298	.278	
	.029	Perm. set.	Wt. rem'd.
6,000	1.578	.280	
	.030	Perm. set.	Wt. rem'd.
7,000	1.887	.309	
	.060	Perm. set.	Wt. rem'd.
8,000	2.300	.413	
	.183	Perm. set.	Wt. rem'd.
9,000	3.540	1.240	
9,500	5.298	1.758	
10,000			Beam sunk slowly, top flange yield'g.

9 inch Beam.
87 lbs per yd. Area 8.7 sq. in.
Clear Span 21 feet.

Centre load in lbs.	Deflecti'n inches.	Increase inches.	Remarks.
2,000	.228		
4,000	.474	.246	
6,000	.720	.246	
8,000	.962	.242	
10,000	1.201	.239	
	.048	Perm. set.	Wt. rem'd.
12,000	1.432	.231	
	.050	Perm. set.	Wt. rem'd.
13,000	1.580	.148	
	.117	Perm. set.	Wt. rem'd.
14,000	1.863	.283	
	.269	Perm. set.	Wt. rem'd.
16,000	3.256	1.393	
17,000	5.233	1.977	Side deflection begins.
17,500	5.602	.369	Beam yields slowly at this load.

9 inch Beam.
150 lbs. per yard. Area 15 sq. inch.
Clear Span 14 feet.

Centre load in lbs.	Deflection inches.	Increase inches.	Remarks.
5,608	.102		
6,720	.126	.024	
7,840	.148	.022	
8,960	.170	.022	
10,080	.192	.022	
11,200	.214	.022	
12,320	.239	.025	
13,440	.261	.022	
14,560	.287	.026	
15,680	.310	.023	
16,800	.336	.026	
17,920	.359	.023	
19,040	.382	.023	
20,160	.409	.027	
21,280	.435	.026	
22,400	.458	.023	
23,520	.487	.029	
24,640	.516	.029	
25,760	.543	.027	
26,880	.572	.029	
28,000	.600	.038	
29,120	.633	.033	Load left stand ¾ hour.
29,120	.682	.049	
	.082	Perm.set.	Wt. rem'd.

15 inch Beam. 200 lbs. per yard.
Area 20 square inches.
Clear Span 14 feet.

Centre load in lbs.	tons.	Deflection inches.	Increase inches.
6,720	3	.048	
8,960	4	.060	.012
11,200	5	.073	.013
13,440	6	.090	.017
15,680	7	.105	.015
17,920	8	.120	.015
20,160	9	.134	.014
22,400	10	.148	.014
24,640	11	.161	.013
26,880	12	.178	.017
29,120	13	.191	.013
31,360	14	.206	.015
33,609	15	.222	.016
35,840	16	.234	.012
38,080	17	.246	.012
40,329	18	.258	.012
42,660	19	.271	.015
44,800	20	.287	.016
47,040	21	.305	.018

Weight removed. Permanent set .016. After lapse of one hour the load of 15 tons was replaced, and caused a total deflection of .222 inches as before.

12 inch Beam. 125 lbs. per yard.
Area 12½ square inches.
Clear Span 27 feet.

Centre load in lbs.	Deflection inches.	Increase inches.
6,720	.691	
7,840	.821	.130
8,960	.948	.127
10,080	1.061	.113
11,200	1.186	.125
12,320	1.328	.142
13,340	1.466	.138
14,560	1.630	.164
15,680	1.800	.170
16,800	1.976	.176
17,920	2.228	.252
19,040	2.455	.227
20,160	2.742	.287
20,720	2.900	.158
20,720	2.965	.065

Last load left on fifteen minutes. Deflection increasing to 2.965.

15 inch Beam. 155 lbs. per yard.
Area 15½ square inches.
Clear Span 27 feet.

Centre load in lbs.	Deflection inches.	Increase inches.
6,720	.342	
7,840	.402	.060
8,960	.462	.060
10,080	.523	.061
11,200	.580	.057
12,320	.639	.059
13,440	.707	.068
14,560	.778	.071
15,680	.845	.067
16,800	.913	.068
17,920	.992	.079
19,040	1.063	.071
20,160	1.149	.086
22,400	1.309	.160
24,640	1.505	.196
25,760	1.603	.098

Load removed. Deflection decreased to .261 permanent set after lapse of half an hour.

The general formulæ for deflections given below are taken from Professor Moseley's "Mechanics of Engineering," edited by Professor Mahan, in 1856, changing the letters which he has employed to agree with those used in this work.

Let l = The clear span in inches.
E = Modulus of elasticity = 24,000,000 lbs. = 12,000 tons.
I = Moment of inertia for the several forms.
δ = Deflection at middle in inches.
W = Load in lbs. producing deflection.
a = Area, and d = depth of beam in inches.

Then, for a beam fixed at one end and loaded at the other,

$$\delta = \frac{W l^3}{3 E I}$$

For a beam fixed at one end and uniformly loaded,

$$\delta = \frac{W l^3}{8 E I}$$

For a beam supported at both ends and loaded at the centre,

$$\delta = \frac{W l^3}{48 E I}$$

For a beam supported at both ends and uniformly loaded,

$$\delta = 5/8 \times \frac{W l^3}{48 E I}$$

For the several sections of beams the value of I will be as follows:

1.  $I = \frac{b\,d^3}{12}$

2.  $I = \frac{b\,d^3 - b'\,d'^3}{12}$

3.  $I = .7854\,r^4 = \frac{a\,r^2}{4}$

4.  $I = .7854\,(r^4 - r'^4)$

5.  $I = 1/3 \left\{ bd^3 + b'd'^3 - (b'-b)\,d'^3 \right\}$

6.  $I = \frac{b\,d^3 - b'\,d'^3}{12}$

By substituting, in formula 6, the effective areas of flange and stem

$$I = \frac{d^2 \left(a + \frac{a'}{6}\right)}{12} = \frac{d^2}{12} \left(a + \frac{a'}{6}\right)$$

Then for shape 6, supported at both ends and loaded at the centre,

$$\delta = \frac{W l^3}{48 \times 12{,}000 \times \frac{d^2}{12} \left(a + \frac{a'}{6}\right)}$$

But l = clear span in inches.

Let L = clear span in feet = 12 l. Then $L^3 = 1728\, l^3$, and

$$\delta = \frac{W L^3}{27.78\,(6a + a')\,d^2} = \frac{.036\,W L^3}{(6a + a')\,d^2} = \frac{.006\,W L^3}{\left(a + \frac{a'}{6}\right) d^2}$$

and for shape 6, supported at both ends and uniformly loaded,

$$\delta = \frac{.004\,W L^3}{\left(a + \frac{a'}{6}\right) d^2}$$

In this form the formula for deflection will be found in the table of beams—table I.

TENSION.

The tensile strength of bars is properly determined by ascertaining the load per square inch under which permanent set takes place and the amount of stretch under the proof-load rather than from the ultimate strength of the bar. Tough, fibrous iron is what is required in a tension bar, and anything of a crystalline nature, although it may show greater ultimate strength under a gradually applied load, is not desirable, for the reason that a suddenly applied strain may cause it to snap under a weight that it ought to carry with entire safety. The annexed table gives the results attained in testing with the proof-load of 20,000 pounds per square inch a number of bars for the International Bridge over the Niagara river, near Buffalo, N. Y. The recovery of each bar, after the removal of the load, was perfect, no permanent set occurring at less than 25,000 pounds. It will be observed that the stretch per foot of the flat bars is less than that of the rounds, giving them higher moduli of elasticity. The ultimate strength of round bars is, however, a little greater than flats, but the strain under which permanent set occurs is about the same in either case for equally good qualities of iron.

TABLE OF TESTS FOR TENSILE STRENGTH.

No. of Bars.	Size.	Length.	Stretch. Inches.	Modulus of Elasticity.
23	3 × $\frac{7}{8}$	35′ 0″	.2587	32,470,000
24	$3\frac{1}{2}$ × $1\frac{1}{8}$	35′ 0″	.2617	32,098,000
9	4 × $1\frac{3}{16}$	27′ 6″	.2033	32,464,700
24	$3\frac{1}{2}$ × $1\frac{1}{4}$	35′ 0″	.2500	33,600,000
24	3 × $\frac{3}{4}$	35′ 0″	.2633	31,902,000
12	4 × $1\frac{1}{8}$	35′ 0″	.2692	31,203,000
24	2 × 1	24′ $9\frac{1}{2}$″	.1948	30,544,000
36	$2\frac{7}{8}$	11′ 9″	.0953	29,380,000
48	$2\frac{1}{2}$	11′ 9″	.0955	29,319,000
68	$2\frac{3}{4}$	11′ 11″	.0998	28,056,000
48	$2\frac{1}{4}$	11′ 9″	.1008	27,777,777
72	$2\frac{3}{8}$	11′ 9″	.0940	29,787,000
120	$2\frac{5}{8}$	11′ 9″	.0947	29,567,000

FORMULÆ.

For Wrought Iron Columns, - - $W = \frac{F A}{1 + \frac{1}{3000} \left(\frac{l}{h}\right)^2}$

For Cast Iron, - - - - - - - $W = \frac{F A}{1 + \frac{1}{400} \left(\frac{l}{h}\right)^2}$

W = Breaking load in lbs.; $\frac{W}{4}$ = Safe load for Wrought,

and $\frac{W}{6}$ = Safe load for Cast Iron.

F = { 50,000 lbs. for Wrought Iron.
80,000 lbs. for Cast Iron.

A = Sectional area of metal, in square inches.

l = length.

h = diameter.

$\frac{l}{h}$ = length in terms of the diameter.

In order to find the load which a Cast or Wrought Iron Column will sustain with safety, ascertain first the number of times its diameter will divide into its length; seek for the quotient in column I, of the Table, and on the same line in column IV or V, (according as the material shall be Cast or Wrought Iron,) the safe load on each square inch of its cross section may be taken; multiply by the number of square inches contained in the cross section for the total safe load.

TABLE

EXHIBITING THE COMPARATIVE STRENGTH OF WROUGHT AND CAST IRON COLUMNS.

COMPUTED FROM GORDON'S FORMULÆ.

F = 50,000 lbs. for Wrought Iron.

Ratio of Length to Diameter.	Maximum Load. Per Square Inch.		Safe Load. Per Square Inch.	
$\frac{l}{k}$	Cast W = lbs.	Wrought W = lbs.	Cast Factor $\frac{1}{6}=\frac{w}{6}$	Wrought Factor $\frac{1}{4}=\frac{w}{4}$
I.	II.	III.	IV.	V.
8	68.965	48.971	11.494	12.243
9	66.528	48.685	11.088	12.171
10	64.000	48.402	10.666	12.100
11	61.420	48.076	10.236	12.019
12	58.823	47.709	9.804	11.927
13	56.289	47.348	9.381	11.837
14	53.691	46.948	8.948	11.737
15	51.200	46.511	8.533	11.628
16	48.780	46.082	8.130	11.520
17	46.444	45.620	7.741	11.405
18	44.198	45.248	7.349	11.312
19	42.050	44.642	7.008	11.160
20	40.000	44.130	6.666	11.032
21	38.049	43.591	6.341	10.898
22	36.199	43.066	6.033	10.766
23	34.445	42.517	5.741	10.629
24	32.789	41.946	5.465	10.486
25	31.219	41.390	5.203	10.347
26	29.739	40.816	4.957	10.204
27	28.343	40.225	4.724	10.056
28	27.027	39.651	4.505	9.913
29	25.785	39.062	4.298	9.765
30	24.617	38.461	4.103	9.615
31	23.512	37.878	3.919	9.469
32	22.479	37.285	3.747	9.321
33	21.491	36.683	3.582	9.171
34	20.565	36.101	3.428	9.025
35	19.692	35.511	3.282	8.878
36	18.869	34.916	3.145	8.729
37	18.090	34.340	3.015	8.585
38	17.353	33.760	2.892	8.440
39	16.658	33.178	2.777	8.294
40	16.000	32.616	2.667	8.154





PRICE CURRENT.



SUBJECT TO CHANGES OF MARKET

WITHOUT NOTICE.



I BEAMS.

Plate No. 1.





Shape.	No. on Plate No. 1	Height in Inches.	Width of Flange.	Thickness of Web.	Sectional Area. Sq. Inches	Weight per Foot.	Ordinary length Feet.	Price per pound.
	100	4	2	.20	1.8	6	30	
	65	4	2¾	.25	3.0	10	30	
	105	5	2¾	.25	3.0	10	30	
	106	5	3	.30	3.6	12	30	
	8	6	2¾	.25	4.0	13⅓	30	
	7	7	3½	.35	5.5	18⅓	30	
	59	8	4	.38	6.5	21⅔	30	
	6	9	3½	.31	7.0	23⅓	30	
	5	9	4	.40	8.4	28	30	
	4	9	5⅜	.60	15.0	50	30	
	58	10½	4½	.44	10.5	35	30	
	57	12	4¾	.49	12.5	41⅔	25	
	55	12	5½	.59	17.0	56⅔	25	
	89	15	4¾	.50	15.0	50	20	
	1	15	5 5/16	.65	20.0	66⅔	20	

One-fourth cent per pound additional (on the whole length and weight of same) for each five feet or any fraction thereof above ordinary lengths. Any beam in the above list can be rolled ten per cent. in excess of the weight given, but not lighter.

DECK BEAMS

Plate No. 2.

SHAPE.	No. on Plate No. 1.	Height in Inches.	Width of Flange.	Thickness of Web for Min. Wt.	Sectional Area. Sq. Inches.	Weight per foot. Min. Max.	Ord. Length in feet.	Price per pound.
	64	5	3	$\frac{3}{8}$	3.5	$11\frac{2}{3}$ to $13\frac{1}{3}$	30	
	63	6	$3\frac{1}{2}$	$\frac{3}{8}$	4.2	14 to $15\frac{2}{3}$	30	
	62	7	4	$\frac{7}{16}$	5.1	17 to 21	30	
	90	7	5	$\frac{7}{16}$	6.3	21 to $24\frac{1}{3}$	30	
	61	8	$4\frac{1}{2}$	$\frac{7}{16}$	6.6	22 to $26\frac{2}{3}$	30	
	60	9	$4\frac{3}{8}$	$\frac{7}{16}$	6.9	23 to $26\frac{2}{3}$	30	
	88	10	5	$\frac{7}{16}$	8.5	$18\frac{1}{3}$ to 35	30	
	104	$11\frac{1}{2}$	5	$\frac{7}{16}$	9.5	$31\frac{2}{3}$ to $37\frac{1}{3}$	30	

One-fourth cent per pound additional (on the whole length and weight of same) for each five feet or any fraction thereof above ordinary lengths. The sectional areas given correspond to the minimum weights.

CHANNEL BARS.

Plate No. 3.

SHAPE.	No. on Plate No. 3.	Height in Inches.	Width of Flange.	Thickness of Web for Min. Wt.	Sec. Area Sq. Inches.	Weight per foot in Lbs. Min. Max.	Ord. Length feet.	Price per lb.
	51	6	$2\frac{1}{16}$	$\frac{5}{16}$	3.3	11 to 14	30	
	50	6	$2\frac{3}{16}$	$\frac{7}{16}$	4.2	14 to 16	30	
	48	6	$2\frac{1}{2}$	$\frac{1}{2}$	4.7	$15\frac{2}{3}$ to 18	30	
	49	6	$2\frac{5}{8}$	$\frac{9}{16}$	5.6	$18\frac{2}{3}$ to 22	30	
	53	9	$2\frac{3}{4}$	$\frac{1}{2}$	7.0	$23\frac{1}{3}$ to $33\frac{1}{3}$	30	
	97	$10\frac{1}{2}$	$3\frac{3}{8}$ / $2\frac{3}{8}$	$\frac{3}{8}$	6.0	20	20	
	52	12	3	$\frac{1}{2}$	8.8	$29\frac{1}{3}$ to 50	25	

NOTE.—If the thickness of the web of Channel iron is increased, the flanges will be correspondingly widened. No. 97 cannot be altered.

One-fourth cent per pound additional (on the whole length and weight of same) for each five feet or any fraction thereof above ordinary lengths.

ADDITIONAL EXTRAS ON

BEAMS AND CHANNELS.

Ordinary Punching ¼ cent lb. Ordinary Fitting ¼ cent lb.
Ordinary Fitting and Punching ⅜ cent lb.
Wrought Iron Fittings 10 cent lb. Cast Separators 5 cent lb.
Special Fitting and Punching at shop rates.

T BARS.



Plate No. 4.



No. on Plate No. 4.	DIMENSIONS.	Weight per foot in Lbs.	Ordinary Length.	Price per Lb.
47	$2\frac{1}{8} \times 1\frac{3}{16} \times \frac{3}{16}$	$2\frac{1}{6}$	20	
103	$2 \times 2 \times \frac{1}{4}$	3	25	
84	$2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{8}$	$5\frac{1}{3}$	25	
98	$2\frac{1}{2} \times 2\frac{3}{4} \times \frac{3}{8}$	6	25	
102	$3 \times 3 \times \frac{7}{16}$	7	25	
24	$3 \times 3\frac{1}{2} \times \frac{1}{2}$	10	25	
45	$3 \times 3\frac{3}{4} \times \frac{1}{2}$	$10\frac{2}{3}$	25	
99	$3\frac{1}{8} \times 2\frac{3}{4} \times \frac{1}{2}$	$9\frac{1}{2}$	25	
101	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{2}$	$9\frac{1}{2}$	25	
85	$4 \times 2 \times \frac{1}{4}$	$5\frac{1}{2}$	25	
46	$4 \times 3\frac{3}{4} \times \frac{7}{8}$	$16\frac{1}{3}$	25	
25	$5 \times 2\frac{3}{8} \times \frac{3}{8}$	$9\frac{2}{3}$	25	
23	$5 \times 2\frac{3}{4} \times \frac{9}{16}$	$11\frac{2}{3}$	25	

NOTE.—The above patterns do not admit of any variation in their dimensions.

ANGLE IRON.

EVEN LEGS.





Plate No. 5.

No. on Plate No. 5.	DIMENSIONS.	Weight per foot in Lbs. Min.	Max.	Ordin'y Length.	Price per Lb.
40	1 × 1 × $\frac{1}{8}$ to $\frac{3}{16}$	.8	1.2	16	
39	$1\frac{1}{4}$ × $1\frac{1}{4}$ × $\frac{1}{8}$ to $\frac{3}{16}$	.9	1.4	16	
20	$1\frac{1}{2}$ × $1\frac{1}{2}$ × $\frac{5}{32}$ to $\frac{1}{4}$	$1\frac{1}{2}$	2.3	25	
19	$1\frac{3}{4}$ × $1\frac{3}{4}$ × $\frac{3}{16}$ to $\frac{5}{16}$	2	$3\frac{1}{2}$	25	
18	2 × 2 × $\frac{7}{32}$ to $\frac{3}{8}$	3	$4\frac{1}{2}$	25	
38	$2\frac{1}{4}$ × $2\frac{1}{4}$ × $\frac{5}{16}$ to $\frac{7}{16}$	$4\frac{1}{4}$	$6\frac{1}{4}$	25	
17	$2\frac{1}{2}$ × $2\frac{1}{2}$ × $\frac{5}{16}$ to $\frac{7}{16}$	5	7	25	
37	$2\frac{3}{4}$ × $2\frac{3}{4}$ × $\frac{3}{8}$ to $\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	25	
16	3 × 3 × $\frac{3}{8}$ to $\frac{1}{2}$	$7\frac{1}{4}$	$9\frac{3}{4}$	25	
15	$3\frac{1}{2}$ × $3\frac{1}{2}$ × $\frac{3}{8}$ to $\frac{9}{16}$	$8\frac{1}{2}$	12	25	
14	4 × 4 × $\frac{7}{16}$ to $\frac{5}{8}$	11	$15\frac{1}{2}$	25	

NOTE.—The lengths of *the legs* of Angle Iron correspond only to the *minimum* thickness given in table; they increase in length as the thickness approaches the maximum. Orders should therefore specify either the thickness or weight per foot, but never both. When thickness is specified, the weights above given are only approximate.

ANGLE IRON.

UNEVEN LEGS.




Plate No. 6.

No. on Plate No. 6.	DIMENSIONS.	Weight per foot in Lbs. Min.	Max.	Ordin'y Length.	Price per Lb.
96	$2\frac{1}{4} \times 1\frac{1}{2} \times \frac{3}{16}$ to $\frac{1}{4}$	$2\frac{1}{2}$	3	25	
109	$3 \times 2 \times \frac{1}{4}$ to $\frac{5}{16}$	4	5	25	
86	$3 \times 2\frac{1}{2} \times \frac{5}{16}$ to $\frac{1}{2}$	$5\frac{1}{3}$	$8\frac{1}{3}$	25	
95	$3\frac{1}{2} \times 3 \times \frac{3}{8}$ to $\frac{9}{16}$	$7\frac{2}{3}$	11	25	
44	$4 \times 3 \times \frac{3}{8}$ to $\frac{9}{16}$	$8\frac{1}{3}$	12	25	
94	$4 \times 3\frac{1}{2} \times \frac{3}{8}$ to $\frac{9}{16}$	9	13	25	
43	$4\frac{1}{2} \times 3 \times \frac{3}{8}$ to $\frac{9}{16}$	9	13	25	
42	$5 \times 3 \times \frac{7}{16}$ to $\frac{9}{16}$	10	14	25	
93	$5 \times 3\frac{1}{2} \times \frac{7}{16}$ to $\frac{9}{16}$	$11\frac{2}{3}$	15	25	
41	$5 \times 4 \times \frac{7}{16}$ to $\frac{5}{8}$	$12\frac{1}{2}$	17	25	
92	$6 \times 3\frac{1}{2} \times \frac{3}{8}$ to $\frac{9}{16}$	$11\frac{1}{3}$	$16\frac{2}{3}$	25	
91	$6 \times 4 \times \frac{7}{16}$ to $\frac{5}{8}$	14	$19\frac{1}{2}$	25	
87	$6\frac{1}{2} \times 4 \times \frac{7}{16}$ to $\frac{5}{8}$	$14\frac{2}{3}$	$20\frac{2}{3}$	25	

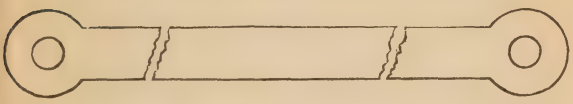
See foot note page 58.

MISCELLANEOUS SHAPES.

Plate Nos. 7 and 3.

SHAPE.	No. on Plate No. 7.	DIMENSIONS.	Weight per foot.	Ordinary Length.	Price per Lb.
	32	$2\frac{1}{2} \times 1\frac{1}{4} \times \frac{1}{4}$	3	14	
	33	$1\frac{3}{4} \times \frac{3}{4} \times \frac{3}{16}$	$1\frac{1}{2}$	14	
	34	$1\frac{3}{4} \times 1\frac{1}{4} \times \frac{3}{16}$	2	14	
	35	$1\frac{7}{8} \times \frac{7}{8} \times \frac{7}{8}$	$1\frac{2}{3}$	14	
	36	$2\frac{1}{4} \times \frac{3}{4} \times \frac{1}{8}$	2	14	
	56	$2\frac{1}{8} \times \frac{1}{2}$	3	14	
		$1\frac{1}{2} \times 1\frac{1}{2}$	3	14	
	Plate No. 3. 107 / 108	$7\frac{1}{4} \times \frac{3}{16}$ to $\frac{1}{2}$ Slight difference in shape.	5 to 15	30	

PATENT LINKS.



TO FORM BOTTOM CHORDS, &c.

FOR BRIDGES.

Flat and Round Links and Eye Bars.

MADE BY HYDRAULIC PRESSURE WITHOUT WELDING.

ALSO,

LONG BRIDGE BOLTS

WITH UPSET ENDS.

SUBJECT TO NEGOTIATION.

LIST OF SIZES

WITH EYES AND SCREW ENDS,



Forged without Welding, by Hydraulic Power,

AT THE PHŒNIX IRON WORKS.

EYES ON ROUND BARS.				EYES ON ROUND BARS.			
Bars.	Eyes.	Pins.	Mark.	Bars.	Eyes.	Pins.	Mark.
Inch	Inch	Inch		Inch	Inch	Inch	
1 1/4	2 3/4 × 1 1/4	1 7/16	B1	2 5/8	6 1/2 × 2 1/2	3 1/4	B35
1 5/8	4 5/8	1 5/8	B10	2 7/8	6 7/8	2 3/4	3 1/4	B36
1 7/8	4 5/8	1 3/4	B11	2 3/4	6 5/8	2 5/8	3 1/4	B38
2 1/8	5	2	1 3/4	B12	2 1/2	6 3/8	2 3/8	3 1/4	B39
1 7/16	3 1/16	1 5/16	2	B3	3 1/8	7 1/2	3	3 1/2	B17
1 5/8	4	1 1/2	2	B27	2 5/8	7	2 1/2	3 1/2	B18
1 3/4	4 1/4	1 5/8	2	B28	2 3/8	6 5/8	2 1/4	3 1/2	B19
1 3/8	3 3/4	1 1/4	2	B59	2 5/8	6 1/4	2	3 1/2	B24
1 7/8	4 3/16	1 3/4	2 1/8	B4	3 3/8	7 3/4	3 1/4	3 1/2	B21
2 1/4	5 1/8	2 1/8	2 1/4	B30	3 1/2	8	3 3/8	3 1/2	B23
2 1/2	5 3/8	2 3/8	2 1/4	B31	2 7/8	7 1/4	2 3/4	3 1/2	B20
2 3/4	5 1/4	2 3/8	2 1/4	B32	2 1/2	6 1/2	2 3/8	3 5/8	B40
1 7/8	5	1 3/4	2 1/2	B15	2 5/8	7 3/8	2 3/8	3 3/4	B41
2 1/8	5 1/2	2	2 1/2	B16	3	7 1/2	2 7/8	3 3/4	B42
2 5/8	5 3/8	2 1/4	2 1/2	B25	3 1/8	7 3/8	3	3 3/4	B43
1 7/8	5 1/2	1 3/4	3	B2	3 1/4	7 3/4	3 1/8	3 3/4	B44
2 1/2	6 1/4	2 3/8	3	B54	2 5/8	7	2 1/4	4	B45
2 1/4	6	2 1/8	3	B55	2 5/8	7 1/4	2 1/2	4	B46
2	5 3/4	1 7/8	3	B56	2 3/4	7 1/2	2 5/8	4	B47
2 7/8	6 3/4	2 3/4	3	B26	3	7 2/3	2 7/8	4	B48
1 3/4	5 1/2	1 5/8	3	B57	3 1/4	8	3 1/4	4	B49
1 1/2	5 1/4	1 3/8	3	B58	3 3/8	8 1/8	3 1/4	4	B50
1 1/2	5 1/4	1 3/8	3 1/4	B37	3 1/2	8 1/4	3 3/8	4	B51
2 1/8	6	2	3 1/4	B33	3 3/4	8 1/4	3 3/8	4	B52
2 3/8	6 1/4	2 1/4	3 1/4	B34	2 1/4	6 3/4	2 1/8	4	B53

LIST OF SIZES OF LINKS.

FORGED WITHOUT WELDING.

SCREW ENDS ON ROUNDS.

Diam.	Size of Upset.	Threads
Inch	Inch	Per inch
$\frac{5}{8}$	$2\frac{1}{2} \times \frac{3}{4}$	10
$\frac{3}{4}$	3 × 1	8
$\frac{7}{8}$	$3\frac{1}{2} \times 1\frac{1}{8}$	7
1	4 × $1\frac{1}{4}$	7
$1\frac{1}{8}$	$4\frac{1}{2} \times 1\frac{3}{8}$	6
$1\frac{1}{4}$	5 × $1\frac{1}{2}$	6
$1\frac{3}{8}$	6 × $1\frac{3}{4}$	5
$1\frac{1}{2}$	6 × $1\frac{7}{8}$	$4\frac{1}{2}$
$1\frac{5}{8}$	6 × 2	$4\frac{1}{2}$
$1\frac{3}{4}$	7 × $2\frac{1}{8}$	$4\frac{1}{2}$
$1\frac{7}{8}$	7 × $2\frac{1}{4}$	4
2	7 × $2\frac{3}{8}$	4
$2\frac{1}{8}$	8 × $2\frac{1}{2}$	4
$2\frac{1}{4}$	8 × $2\frac{5}{8}$	4
$2\frac{3}{8}$	8 × $2\frac{3}{4}$	$3\frac{1}{2}$
$2\frac{1}{2}$	9 × $2\frac{7}{8}$	$3\frac{1}{2}$
$2\frac{5}{8}$	9 × 3	$3\frac{1}{2}$
$2\frac{3}{4}$	9 × $3\frac{1}{8}$	$3\frac{1}{2}$
$2\frac{7}{8}$	9 × $3\frac{3}{8}$	$3\frac{1}{4}$
3	10 × $3\frac{1}{2}$	$3\frac{1}{4}$
$3\frac{1}{8}$	10 × $3\frac{5}{8}$	$3\frac{1}{4}$
$3\frac{1}{4}$	10 × $3\frac{3}{4}$	3
$3\frac{3}{8}$	11 × $3\frac{7}{8}$	3
$3\frac{1}{2}$	11 × 4	3
$3\frac{5}{8}$	12 × $4\frac{1}{8}$	$2\frac{7}{8}$
$3\frac{3}{4}$	12 × $4\frac{1}{4}$	$2\frac{7}{8}$

EYES ON FLAT BARS.

Bars.	Eyes.	Pins.	Mark.
Inch × Inch	Inch	Inch	
2 × 1	$4\frac{1}{2}$	2	A^{90}
$2\frac{3}{4} \times 1\frac{1}{4}$	$6\frac{1}{8}$	2	A^{38}
$3\frac{1}{8} \times 1\frac{1}{4}$	$6\frac{3}{4}$	$2\frac{1}{8}$	A^{39}
2	5	$2\frac{1}{4}$	A^{51}
$2\frac{1}{2}$	6	$2\frac{1}{4}$	A^{77}
3	$6\frac{3}{4}$	$2\frac{1}{4}$	A^{1}
$3\frac{3}{8} \times 1\frac{1}{4}$	$7\frac{1}{4}$	$2\frac{1}{4}$	A^{40}
$3\frac{1}{2} \times 1\frac{1}{8}$	$7\frac{1}{2}$	$2\frac{1}{4}$	A^{17}
3 × 1	$6\frac{7}{8}$	$2\frac{3}{8}$	A^{82}
3 × $1\frac{1}{8}$	$6\frac{7}{8}$	$2\frac{3}{8}$	A^{83}
3 × $1\frac{1}{4}$	$6\frac{7}{8}$	$2\frac{3}{8}$	A^{84}
2	5	$2\frac{1}{2}$	A^{2}
2 × $1\frac{1}{8}$	5	$2\frac{1}{2}$	A^{50}
$2\frac{1}{2} \times \frac{3}{4}$	$6\frac{1}{4}$	$2\frac{1}{2}$	A^{24}
$2\frac{1}{2} \times 1\frac{1}{16}$	$6\frac{1}{4}$	$2\frac{1}{2}$	A^{105}
$2\frac{1}{2} \times 1\frac{1}{4}$	$6\frac{1}{4}$	$2\frac{1}{2}$	A^{133}
$3\frac{1}{2} \times 1\frac{5}{16}$	$7\frac{3}{4}$	$2\frac{1}{2}$	A^{104}
4 × $1\frac{9}{16}$	$8\frac{1}{2}$	$2\frac{1}{2}$	A^{121}
$1\frac{3}{8} \times 1\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{5}{8}$	A^{43}
$1\frac{5}{8} \times 1\frac{1}{4}$	$5\frac{3}{4}$	$2\frac{5}{8}$	A^{42}
3 × 1	$7\frac{1}{8}$	$2\frac{5}{8}$	A^{18*}
3 × $1\frac{1}{4}$	$7\frac{1}{8}$	$2\frac{5}{8}$	A^{41}
$3\frac{1}{2} \times 1$	$7\frac{1}{8}$	$2\frac{5}{8}$	A^{54}
$3\frac{1}{2} \times 1\frac{1}{2}$	$7\frac{7}{8}$	$2\frac{5}{8}$	A^{35}
$2\frac{1}{2} \times 1$	$6\frac{1}{2}$	$2\frac{3}{4}$	A^{134}
$2\frac{1}{2} \times \frac{7}{8}$	$6\frac{1}{2}$	$2\frac{3}{4}$	A^{135}
4 × $1\frac{5}{16}$	$8\frac{3}{4}$	$2\frac{3}{4}$	A^{120}
3 × $1\frac{1}{16}$	$7\frac{1}{4}$	$2\frac{3}{4}$	A^{122}
3 × $1\frac{3}{8}$	$7\frac{1}{4}$	$2\frac{3}{4}$	A^{123}
3 × $1\frac{9}{16}$	$7\frac{1}{4}$	$2\frac{3}{4}$	A^{124}
2 × 1	$5\frac{1}{2}$	3	A^{89}
3 × $\frac{3}{4}$	$7\frac{1}{2}$	3	A^{33}
3 × $\frac{7}{8}$	$7\frac{1}{2}$	3	A^{136}
3 × 1	7	3	A^{18}
3 × $1\frac{1}{2}$	7	3	A^{88}
$3\frac{1}{2} \times \frac{7}{8}$	$8\frac{1}{4}$	3	A^{30}
$3\frac{1}{2} \times 1\frac{9}{16}$	$8\frac{1}{4}$	3	A^{11}
4 × 1	9	3	A^{23}

All threads are one-sixteenth of an inch larger in diameter at their root than the diameter of the rod.

LIST OF SIZES OF LINKS,

FORGED WITHOUT WELDING.

EYES ON FLAT BARS.

Bars.	Eyes.	Pins.	Mark.
Inch	Inch	Inch	
$4\frac{1}{2} \times 1$	$9\frac{3}{4}$	3	A^{21}
5 $1\frac{1}{4}$	$10\frac{1}{2}$	3	A^{46}
3 $\frac{7}{8}$	$7\frac{3}{4}$	$3\frac{1}{4}$	A^{54}
3 $1\frac{1}{8}$	$7\frac{3}{4}$	$3\frac{1}{4}$	A^{118}
$3\frac{1}{2}$ 1	$8\frac{1}{2}$	$3\frac{1}{4}$	A^{116}
$3\frac{1}{2}$ $1\frac{1}{4}$	$8\frac{1}{2}$	$3\frac{1}{4}$	A^{53}
$3\frac{1}{2}$ $1\frac{7}{8}$	$8\frac{1}{2}$	$3\frac{1}{4}$	A^{117}
4 $1\frac{7}{8}$	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{78*}
4 1	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{78}
4 $1\frac{1}{8}$	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{79}
4 $1\frac{2}{8}$	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{52}
4 $1\frac{2}{8}$	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{80}
4 $1\frac{7}{8}$	$9\frac{1}{4}$	$3\frac{1}{4}$	A^{81}
3 $\frac{3}{4}$	$7\frac{1}{2}$	$3\frac{1}{2}$	A^{8}
3 $\frac{7}{8}$	8	$3\frac{1}{2}$	A^{106}
3 $1\frac{1}{8}$	8	$3\frac{1}{2}$	A^{107}
3 $1\frac{2}{8}$	8	$3\frac{1}{2}$	A^{49}
$3\frac{1}{2}$ $\frac{7}{8}$	$8\frac{3}{4}$	$3\frac{1}{2}$	A^{29}
4 1	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{108}
4 $1\frac{1}{4}$	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{109}
4 $1\frac{7}{16}$	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{110}
4 $1\frac{1}{2}$	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{48}
4 $1\frac{2}{8}$	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{96}
4 $2\frac{1}{8}$	$9\frac{1}{2}$	$3\frac{1}{2}$	A^{87}
5 1	11	$3\frac{1}{2}$	A^{91*}
5 $1\frac{2}{8}$	11	$3\frac{1}{2}$	A^{47}
3 $1\frac{1}{16}$	$8\frac{1}{4}$	$3\frac{3}{4}$	A^{59}
4 $1\frac{1}{4}$	$9\frac{3}{4}$	$3\frac{3}{4}$	A^{58}
4 $1\frac{2}{8}$	$9\frac{3}{4}$	$3\frac{3}{4}$	A^{60}
4 2	$9\frac{3}{4}$	$3\frac{3}{4}$	A^{61}
$4\frac{1}{2}$ $1\frac{5}{16}$	$10\frac{1}{2}$	$3\frac{3}{4}$	A^{62}
$4\frac{1}{2}$ $1\frac{9}{16}$	$10\frac{1}{2}$	$3\frac{3}{4}$	A^{63}
$4\frac{1}{2}$ $1\frac{3}{4}$	$10\frac{1}{2}$	$3\frac{3}{4}$	A^{64}
$3\frac{1}{2}$ $1\frac{1}{16}$	$9\frac{1}{4}$	4	A^{101}
$3\frac{1}{2}$ $1\frac{5}{16}$	$9\frac{1}{4}$	4	A^{103}

EYES ON FLAT BARS.

Bars.	Eyes.	Pins.	Mark.
Inch	Inch	Inch	
$3\frac{1}{2} \times 1\frac{1}{2}$	$9\frac{1}{4}$	4	A^{119}
4 1	10	4	A^{97}
4 $1\frac{3}{16}$	10	4	A^{98}
4 $1\frac{1}{16}$	10	4	A^{99}
4 $1\frac{2}{8}$	10	4	A^{55}
4 $2\frac{1}{8}$	10	4	A^{100}
$4\frac{1}{2}$ $1\frac{1}{2}$	$10\frac{1}{2}$	4	A^{74}
5 1	$11\frac{1}{2}$	4	A^{91}
5 $1\frac{2}{16}$	$11\frac{1}{2}$	4	A^{92}
5 $1\frac{3}{16}$	$11\frac{1}{2}$	4	A^{85}
5 $1\frac{3}{4}$	$11\frac{1}{2}$	4	A^{70}
5 2	$11\frac{1}{2}$	4	A^{86}
6 $1\frac{7}{16}$	13	4	A^{102}
6 $1\frac{2}{8}$	13	4	A^{67}
6 2	13	4	A^{68}
6 $2\frac{3}{8}$	13	4	A^{69}
5 $2\frac{1}{8}$	$11\frac{1}{2}$	$4\frac{1}{4}$	A^{128}
5 $2\frac{3}{8}$	$11\frac{1}{2}$	$4\frac{1}{4}$	A^{129}
5 $2\frac{2}{8}$	$11\frac{1}{2}$	$4\frac{1}{4}$	A^{130}
$3\frac{1}{2}$ $1\frac{1}{4}$	$9\frac{1}{2}$	$4\frac{1}{2}$	A^{114}
4 $1\frac{2}{8}$	10	$4\frac{1}{2}$	A^{112}
4 $1\frac{1}{2}$	10	$4\frac{1}{2}$	A^{113}
4 $1\frac{2}{8}$	11	5	A^{73}
4 $1\frac{2}{8}$	11	5	A^{76}
4 2	11	5	A^{72}
$4\frac{1}{2}$ $1\frac{3}{4}$	$10\frac{1}{2}$	5	A^{65}
5 $1\frac{2}{16}$	12	5	A^{93}
5 $1\frac{7}{16}$	$12\frac{1}{2}$	5	A^{94}
5 $1\frac{3}{4}$	$12\frac{1}{2}$	5	A^{71}
5 2	$12\frac{1}{2}$	5	A^{95}
7 $1\frac{1}{2}$	15	5	A^{126}
7 3	15	5	A^{125}
5 2	13	6	A^{127}
5 $2\frac{3}{8}$	$13\frac{1}{2}$	$6\frac{1}{2}$	A^{131}
5 $2\frac{2}{8}$	$13\frac{1}{2}$	$6\frac{1}{2}$	A^{132}

NOTE.—These dies can be used for pins $\frac{1}{8}$ inch less to $\frac{1}{4}$ more in diameter. The sectional area of the eye, being fifty per cent. in excess of that of the bar in nearly all cases, will not be materially changed by such alteration. For new dies the diameter of the pin should not exceed the width of the bar, nor should the thickness be less than one-fourth of the width of the bar.

PRICE OF LINKS.

Links made of Flat, Round or Square Iron, of such shape and sizes as can be made in dies, and having eyes at both ends, and containing sectional areas and lengths, as below:

Not less than $3\frac{1}{2}$ □″ and not less than 15 feet long, add to the price of the bar, cut to length, as delivered from the mill, - - - -	x cents per lb.
Under 15 feet to 12 feet, - -	$x + \frac{1}{4}$ cts. per lb.
" 12 " 10 " - -	$x + \frac{1}{2}$ "
" 10 " N - -	$\frac{10}{N}(x + \frac{1}{2})$ "
For sections less than $3\frac{1}{2}$ □″ to 2 □″ additional extra to above, - -	$\frac{1}{4}$ cent per lb.
For sections less than 2 □″ to $1\frac{1}{2}$ □″ additional extra to above, - -	$\frac{1}{2}$ cent per lb.

1. For sections corresponding with above, which cannot be made in the hydraulic shop, if made in smith shop, add 50 per cent. to hydraulic shop prices.

2. Links of less section than $1\frac{1}{2}$ □″ down to $\frac{3}{8}$ □″ the price varies with the section, and depends upon the specification, etc.

3. Links made in hydraulic shops, with eye at one end and screw at the other, and with nut fitted, $\frac{1}{4}$ cent per lb. less than if eyes at both ends. If made with screws at both ends, including nuts, $\frac{1}{2}$ cent per lb. less than with eyes.

PRICE OF PINS.

Pins, turned and chased for nuts, to the price of the iron cut to lengths, as follows:

For 3″ round and over, and 3 feet long and over, add, - - - y cent per lb.

Under 3 feet to 2 feet long and over, add, y + ½ cent per lb.

" 2 " 1 foot " " " y + 1½ "

For less than 3″ down to 2½″ round, add to above, - - - ½ cent per lb.

For less than 2½″ down to 2″ round, add to above, - - - 1 cent per lb.

For less than 2″ down to 1½″ round, add to above, - - - 2 cent per lb.

Nuts for above pins: price depends on size.

Allowance for lengths of links between eyes, centre to centre, $\frac{1}{64}$ of an inch.

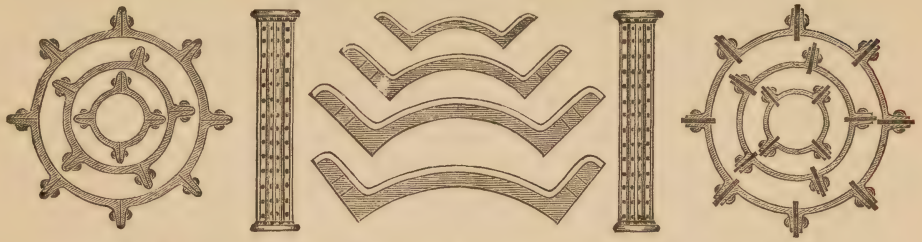
For diameter of pin or pin-hole, $\frac{1}{100}$ of an inch. The pin-hole, however, must be $\frac{1}{50}$ larger than the pin.

The values of x and y vary from time to time, according to the rise or fall of wages.

PHŒNIX PATENT WROUGHT IRON COLUMNS.

MANUFACTURED ONLY AT THE PHŒNIX IRON WORKS.

Engineers and Builders are cautioned against procuring these Columns of any other parties, without permission from this Company.



BOTH ENDS OF EVERY COLUMN FACED OFF TRUE AND PARALLEL.

A. B^1 B^2 and C. are 4 Segments. D. is 5 Segments.

E. is 6 Segments. F. is 7 Segments. G. is 8 Segments.

N. B.—To find the price of any Column under the head of "Extras," add the extra price as provided to the price given for "Ordinary Sizes."

410 WALNUT ST., PHILADELPHIA.

PHŒNIX
PATENT WROUGHT IRON COLUMNS.

C, D, E, F and G Columns.

OVER THREE-EIGHTHS OF AN INCH THICK.

Cross section containing 3½ □ inches, or over, per Segment.

ORDINARY SIZES
10 feet to 20 feet long, } cents per lb.

EXTRAS.

C, D, E, F and G Columns.

OVER THREE-EIGHTHS OF AN INCH THICK.

Cross section containing over 3½ □ inches to each Segment.

Over 20 feet to 30 feet..... ¼c.
Under 10 " 5 " ..... ¼c.

THREE-EIGHTHS TO ONE-QUARTER OF AN INCH THICK.

Cross section containing 3½ to 2½ □ inches per Segment.

AS ABOVE.

10 feet to 20 feet..... ¼c.
Over 20 " 30 " ..... ½c.
Under 10 " 5 " ..... ½c.

B² Columns.

OVER THREE-EIGHTHS OF AN INCH THICK.

Cross section containing 10.6 □ inches, or over.

10 feet to 20 feet..... ½c.
Over 20 " 30 " ..... ¾c.
Under 10 " 5 " ..... ¾c.

THREE-EIGHTHS TO ONE-QUARTER OF AN INCH THICK.

Cross section containing 7.4 □ inches, or over.

10 feet to 20 feet..... ¾c.
Over 20 " 30 " ..... 1 c.
Under 10 " 5 " ..... 1 c.

UNDER ONE-QUARTER TO THREE-SIXTEENTHS OF AN INCH THICK.

Cross section containing less than 7.4 □ inches.

10 feet to 20 feet..... 1 c.
Over 20 " 30 " ..... 1¼c.
Under 10 " 5 " ..... 1¼c.

B¹ Columns.

OVER THREE-EIGHTHS OF AN INCH THICK.

Cross section containing $9\frac{2}{10}$ □ inches, or over.

	10 feet to 20 feet			1 c.
Over	20 "	30 "		1¼ c.
Under	10 "	5 "		1¼ c.

THREE-EIGHTHS TO ONE-QUARTER OF AN INCH THICK.

Cross section containing $6\frac{4}{10}$ □ inches, or over.

	10 feet to 20 feet			1¼ c.
Over	20 "	30 "		1½ c.
Under	10 "	5 "		1½ c.

UNDER ONE-QUARTER TO THREE-SIXTEENTHS OF AN INCH THICK.

Cross section containing less than $6\frac{4}{10}$ □ inches.

	10 feet to 20 feet			1¾ c.
Over	20 "	30 "		2 c.
Under	10 "	5 "		2 c.

A Columns.

THREE-EIGHTHS TO ONE-QUARTER OF AN INCH THICK.

Cross section containing 4.8 □ inches, or over.

	10 feet to 20 feet			2 c.
Over	20 "	30 "		2½ c.
Under	10 "	5 "		2½ c.

UNDER ONE-QUARTER TO THREE-SIXTEENTHS OF AN INCH THICK.

Cross section containing 3.8 □ inches, or over.

	10 feet to 20 feet			2½ c.
Over	20 "	30 "		3 c.
Under	10 "	5 "		3 c.

UNDER THREE-SIXTEENTHS TO ONE-EIGHTH OF AN INCH THICK.

Cross section containing less than 3.8 □ inches.

	10 feet to 20 feet			3 c.
Over	20 "	30 "		3½ c.
Under	10 "	5 "		3½ c.

REFINED BAR IRON—PHŒNIX BEST.

TERMS CASH.

(Subject to the changes of the Market without notice.)

ORDINARY SIZES.

● Rounds and Squares. ■

¾ to 2 inches.

FLATS.

1 to 6 inches × ⅜ to 1
1 to 4 inches × 1⅛ to 2

} cents per pound.

EXTRA SIZES—ORDINARY LENGTHS.

● ROUNDS. ●

2⅛ to 2⅞ ..... $\frac{1}{10}$c.	5¼ to 5½ ..... 1$\frac{4}{10}$c.
3 to 3½ ..... $\frac{3}{10}$c.	5¾ to 6 ..... 1$\frac{8}{10}$c.
3⅝ to 4 ..... $\frac{5}{10}$c.	6¼ to 6½ ..... 2$\frac{2}{10}$c.
4⅛ to 4½ ..... $\frac{7}{10}$c.	6¾ to 7 ..... 2$\frac{7}{10}$c.
4⅝ to 5 ..... $\frac{9}{10}$c.	

■ SQUARES. ■

2⅛ to 2⅞ ..... $\frac{1}{10}$c.	3⅞ to 4 ..... $\frac{7}{10}$c.
3 to 3½ ..... $\frac{3}{10}$c.	4⅛ to 5 ..... 1 c.
3⅝ to 3¾ ..... $\frac{5}{10}$c.	

EXTRA LENGTHS.

EACH ADDITIONAL FOOT.

ROUNDS AND SQUARES.

On 3 to 4 inches longer than 18 feet,
" 4⅛ to 6 " " 16 "
" 6¼ to 7 " " 14 "
} $\frac{1}{10}$c. ℔.

PHŒNIX BEST BAR IRON.

EXTRA SIZES—ORDINARY LENGTHS.

FLATS.

1	to 6	×	¼	&	$\frac{5}{16}$	.....	$\frac{2}{10}$c.
2¼	to 3	×	2⅛	to	2¾	.....	$\frac{2}{10}$
3¼	to 4½	×	2⅛	to	3¾	.....	$\frac{3}{10}$
4½	to 6	×	1⅛	to	2	.....	$\frac{2}{10}$
5	to 6	×	2¼	to	3½	.....	$\frac{4}{10}$

6½	×	¼	to	1	..	$\frac{3}{10}$c.	9¼	×	1¼	to	2¾ .. 1$\frac{1}{10}$c.
6½	×	1¼	to	2½	..	$\frac{4}{10}$	9½	×	¼	to	1 .. $\frac{2}{10}$
7	×	¼	to	1	..	$\frac{4}{10}$	9½	×	1¼	to	2¾ .. 1$\frac{1}{10}$
7	×	1¼	to	3½	..	$\frac{6}{10}$	10	×	¼	to	1 .. 1
7½	×	¼	to	1	..	$\frac{5}{10}$	10	×	1¼	to	2¾ .. 1$\frac{1}{10}$
7½	×	1¼	to	2	..	$\frac{7}{10}$	10½	×	¼	to	1 .. 1$\frac{1}{10}$
8	×	¼	to	1	..	$\frac{6}{10}$	10½	×	1¼	to	2¾ .. 1$\frac{2}{10}$
8	×	1¼	to	2¾	..	$\frac{8}{10}$	11¼	×	¼	to	1 .. 1$\frac{2}{10}$
8½	×	¼	to	1	..	$\frac{8}{10}$	11¼	×	1¼	to	2¾ .. 1$\frac{3}{10}$
8½	×	1¼	to	2	..	$\frac{8}{10}$	11½	×	¼	to	1 .. 1$\frac{3}{10}$
9	×	¼	to	1	..	$\frac{8}{10}$	11½	×	1¼	to	2¾ .. 1$\frac{4}{10}$
9	×	1¼	to	2	..	$\frac{9}{10}$	12	×	¼	to	1 .. 1$\frac{4}{10}$
9¼	×	¼	to	1	..	$\frac{9}{10}$	12	×	1¼	to	2¾ .. 1$\frac{5}{10}$

ADDITIONAL EXTRAS.

CUTTING TO LENGTHS

ROUNDS AND SQUARES.

Up to 4 inches..... $\frac{2}{10}$c.
Over 4 " ..... $\frac{4}{10}$

Under 10 feet, special agreement.

FLATS.

Up to 6 inches wide, from 10 to 20 feet..... $\frac{2}{10}$ c.
Over 6 " " " ..... $\frac{3}{10}$

Under 10 and over 20 feet, special agreement.

VALUE OF IRON.

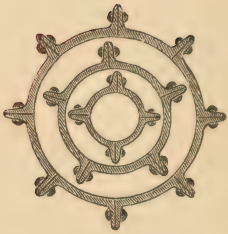
Value per gross ton (2240 pounds) of Iron, at from one-sixteenth of a cent to twelve cents per pound, increasing at the rate of one-sixteenth and one-eighth of a cent per pound.

Per lb.	Price per ton.	Per lb.	Price per ton.	Per lb.	Price per ton.
1/16	$1 40	2 9/16	$57 40	7	$156 80
1/8	2 80	5/8	58 80	1/8	159 60
3/16	4 20	1 1/16	60 20	1/4	162 40
1/4	5 60	3/4	61 60	3/8	165 20
5/16	7 00	1 3/16	63 00	1/2	168 00
3/8	8 40	7/8	64 40	5/8	170 80
7/16	9 80	1 5/16	65 80	3/4	173 60
1/2	11 20	3	67 20	7/8	176 40
9/16	12 60	1/8	70 00	8	179 20
5/8	14 00	1/4	72 80	1/8	182 00
11/16	15 40	3/8	75 60	1/4	184 80
3/4	16 80	1/2	78 40	3/8	187 60
13/16	18 20	5/8	81 20	1/2	190 40
7/8	19 60	3/4	84 00	5/8	193 20
15/16	21 00	7/8	86 80	3/4	196 00
1	22 40	4	89 60	7/8	198 80
1/16	23 80	1/8	92 40	9	201 60
1/8	25 20	1/4	95 20	1/8	204 40
3/16	26 60	3/8	98 00	1/4	207 20
1/4	28 00	1/2	100 80	3/8	210 00
5/16	29 40	5/8	103 60	1/2	212 80
3/8	30 80	3/4	106 00	5/8	218 40
7/16	32 20	7/8	109 20	3/4	224 00
1/2	33 60	5	112 00	10	226 80
9/16	35 00	1/8	114 80	1/8	229 60
5/8	36 40	1/4	117 60	1/4	232 40
11/16	37 80	3/8	120 40	3/8	235 20
3/4	39 20	1/2	123 20	1/2	238 00
13/16	40 60	5/8	126 00	5/8	240 80
7/8	42 00	3/4	128 80	3/4	243 60
15/16	43 40	7/8	131 60	7/8	246 40
2	44 80	6	134 40	11	249 20
1/16	46 20	1/8	137 20	1/8	252 00
1/8	47 60	1/4	140 00	1/4	254 80
3/16	49 00	3/8	142 80	3/8	257 60
1/4	50 40	1/2	145 60	1/2	260 40
5/16	51 80	5/8	148 40	5/8	263 20
3/8	53 20	3/4	151 20	3/4	266 00
7/16	54 60	7/8	154 00	7/8	268 80
1/2	56 00			12	

VALUE OF IRON.

Value per gross ton (2240 pounds) of Iron, at from one-tenth of a cent to twelve cents per pound, increasing at the rate of one-tenth of a cent per pound.

Per lb.	Price per ton.	Per lb.	Price per ton.	Per lb.	Price per ton.
1/10	$2 24	4 1/10	$91 84	8 1/10	$181 44
2/10	4 48	2/10	94 08	2/10	183 68
3/10	6 72	3/10	96 32	3/10	185 92
4/10	8 96	4/10	98 56	4/10	188 16
5/10	11 20	5/10	100 80	5/10	190 40
6/10	13 44	6/10	103 04	6/10	192 64
7/10	15 68	7/10	105 28	7/10	194 88
8/10	17 92	8/10	107 52	8/10	197 12
9/10	20 16	9/10	109 76	9/10	199 36
1	22 40	5	112 00	9	201 60
1/10	24 64	1/10	114 24	1/10	203 84
2/10	26 88	2/10	116 48	2/10	206 08
3/10	29 12	3/10	118 62	3/10	208 32
4/10	31 36	4/10	120 96	4/10	210 56
5/10	33 60	5/10	123 20	5/10	212 80
6/10	35 84	6/10	125 44	6/10	215 04
7/10	38 08	7/10	127 68	7/10	217 28
8/10	40 32	8/10	129 92	8/10	219 52
9/10	42 56	9/10	132 16	9/10	221 76
2	44 80	6	134 40	10	224 00
1/10	47 04	1/10	136 64	1/10	226 24
2/10	49 28	2/10	138 88	2/10	228 48
3/10	51 52	3/10	141 12	3/10	230 72
4/10	53 76	4/10	143 36	4/10	232 96
5/10	56 00	5/10	145 60	5/10	235 20
6/10	58 24	6/10	147 84	6/10	237 44
7/10	60 48	7/10	150 08	7/10	239 68
8/10	62 72	8/10	152 32	8/10	241 92
9/10	64 96	9/10	154 56	9/10	244 16
3	67 20	7	156 80	11	246 40
1/10	69 44	1/10	158 04	1/10	248 64
2/10	71 68	2/10	161 28	2/10	250 88
3/10	73 92	3/10	163 52	3/10	253 12
4/10	76 16	4/10	165 76	4/10	255 36
5/10	78 40	5/10	168 00	5/10	257 60
6/10	80 64	6/10	170 24	6/10	259 84
7/10	82 88	7/10	172 48	7/10	262 08
8/10	85 12	8/10	174 72	8/10	264 32
9/10	87 36	9/10	176 96	9/10	266 56
4	89 60	8	179 20	12	268 80



TABLES

OF

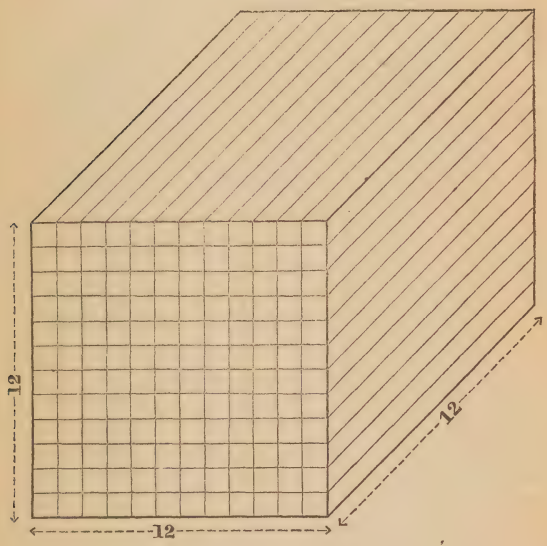
WEIGHTS AND MEASURES.



GENERAL RULE

FOR DETERMINING THE

WEIGHT OF ANY PIECE OF WROUGHT IRON.



One cubic foot of Wrought Iron	- -	= 480	lbs.
One square foot, one inch thick,	= $\frac{480}{12}$	= 40	"
One square inch, one foot long,	= $\frac{40}{12}$	= $3\frac{1}{3}$	"
One square inch, one yard long,	= $3\frac{1}{3} \times 3$	= 10	"

Then to ascertain the weight of any piece of wrought iron, use the following

RULE.

Ten times the sectional area in square inches is equal to the weight in pounds per yard.

WEIGHT OF FLAT BAR IRON.

PER FOOT.

Width in Inches.	Thickness in Inches.											
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	.21	.42	.63	.84	1.05	1.26	1.47	1.68	2.11	2 53	2.95	3.37
1⅛	.24	.47	.71	.95	1.18	1.42	1.66	1.90	2.37	2.84	3.32	3.79
1¼	.26	.53	.79	1.05	1.32	1.58	1.84	2.11	2.63	3 16	3.68	4 21
1⅜	.29	.58	.87	1.16	1.45	1.74	2.03	2.32	2.89	3.47	4.05	4.63
1½	.32	.63	.95	1.26	1.58	1.90	2.21	2.53	3.16	3.79	4.42	5.05
1⅝	.34	.68	1.03	1.37	1.71	2.05	2.39	2.74	3.42	4.11	4.79	5.47
1¾	.37	.74	1.11	1.47	1.84	2.21	2.58	2.95	3 68	4.42	5.16	5.89
1⅞	.40	.79	1.18	1.58	1.97	2.37	2.76	3.16	3.95	4.74	5.53	6.32
2	.42	.84	1.26	1.68	2.11	2.53	2.95	3.37	4.21	5.05	5.89	6.74
2⅛	.45	.90	1.34	1.79	2.24	2.68	3.13	3.58	4.47	5.37	6.26	7.16
2¼	.47	.95	1.42	1.90	2.37	2.84	3.32	3.79	4.74	5.68	6.83	7.58
2⅜	.50	1.00	1.50	2.00	2 50	3.00	3.50	4.00	5.00	6.00	7 00	8.00
2½	.53	1.05	1.58	2 11	2.63	3.16	3.68	4.21	5.26	6.32	7.37	8,42
2⅝	.55	1.11	1.66	2.21	2.76	3.32	3.87	4.42	5.53	6.63	7.74	8.84
2¾	.58	1.16	1.74	2.32	2.89	3.47	4.05	4.63	5.79	6.95	8 10	9.26
2⅞	.61	1.21	1.82	2.42	3.03	3.63	4.24	4.84	6.05	7.26	8.47	9.68
3	.63	1.26	1.90	2.53	3.16	3.79	4.42	5.05	6.32	7.58	8,84	10.10
3¼	.68	1.37	2.05	2.74	3.42	4.11	4.79	5.47	6.84	8.21	9,58	10.95
3½	.74	1.47	2.21	2.95	3.68	4.42	5.16	5.89	7.37	8.84	10,32	11.79
3¾	.79	1.58	2.37	3.16	3.95	4.74	5.53	6.32	7.89	9.47	11.05	12.63
4	.84	1.68	2.53	3.37	4.21	5.05	5.89	6.74	8.42	10.10	11.79	13.47
4¼	.90	1.79	2.68	3.58	4.47	5 37	6.26	7.16	8.95	10.74	12.53	14.31
4½	.95	1.90	2.84	3.79	4.74	5.68	6.63	7.58	9.47	11.38	13.26	15.16
4¾	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	10.00	12.00	14.00	16.00
5	1.05	2.11	3.16	4.21	5.26	6.32	7 37	8.42	10.53	12,63	14.74	16.84
5¼	1.11	2.21	3.32	4.42	5.53	6.63	7.74	8.84	11.05	13.26	15.47	17.68
5½	1,16	2.32	3.47	4.63	5.79	6.95	8.10	9.26	11,58	13.89	16.21	18.52
5¾	1.21	2.42	3.63	4.84	6.05	7.26	8.47	9 68	12 10	14.53	16.95	19.37
6	1.26	2.53	3.79	5.05	6.32	7.58	8.84	10.10	12.63	15,16	17.68	20.21

WEIGHT OF FLAT BAR IRON.

PER FOOT.

Width in Inches.	Thickness in Inches.											
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6¼	1.31	2.63	3.95	5.27	6.58	7.90	9.21	10.53	13.16	15.79	18.42	21.05
6½	1.36	2.73	4.10	5.47	6.84	8.21	9.58	10 94	13.68	16.42	19.16	21.88
6¾	1.42	2.84	4.26	5.69	7.10	8.53	9.95	11.36	14.21	17.05	19.90	22.73
7	1.47	2.94	4.42	5.90	7.36	8.84	10.32	11.79	14.74	17.68	20.64	23.58
7¼	1.53	3.05	4.58	6.11	7.63	9.16	10.68	12.21	15.26	18.32	21.37	24.42
7½	1.58	3.16	4.74	6.32	7.90	9.48	11.06	12.64	15.78	18.94	21.11	25.28
7¾	1.63	3.26	4.90	6.53	8.16	9.79	11.42	13.06	16.31	19.57	22.84	26.12
8	1.68	3.36	5.05	6.74	8.42	10.10	11.78	13.48	16.84	20.20	23.58	26.94
8¼	1.74	3.47	5.21	6.95	8.68	10.42	12.16	13.89	17.37	20.84	24.32	27.79
8½	1.79	3.58	5.36	7.16	8.94	10.74	12.52	14.32	17.90	21.48	25.06	28.63
8¾	1.84	3.68	5.53	7.37	9.21	11.05	12.89	14.74	18.42	22.10	25.79	29.47
9	1.90	3.79	5.68	7.58	9.48	11.36	13.26	15.16	18.95	22.75	26.52	30.32
9¼	1.95	3.90	5.84	7.79	9.74	11.68	13.63	15.58	19.47	23.38	27.26	31.16
9½	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	20.00	24.00	28.00	32.00
9¾	2.05	4.11	6.16	8.21	10.26	12.32	14.37	16.42	20.53	24.63	28.74	32.84
10	2.10	4.21	6.32	8.42	10.52	12.64	14.74	16.84	21.05	25.26	29.48	33.68
10¼	2.16	4.32	6.48	8.63	10.79	12.95	15.11	17.26	21.58	25.89	30.21	34.52
10½	2.21	4.41	6.64	8.84	11.05	13.26	15.48	17.68	22.10	26.52	30.95	35.36
10¾	2.26	4.53	6.79	9.05	11.32	13.58	15.84	18.10	22.63	27.16	31.68	36.21
11	2.32	4.64	6.95	9.26	11.58	13.90	16.21	18.52	23.16	27.78	32.42	37.04
11¼	2.37	4.74	7.11	9.47	11.85	14.21	16.58	18.94	23.68	28.42	33.15	37.89
11½	2.42	4.84	7.26	9.68	12.10	14.52	16.94	19.36	24.20	29.06	33.90	38.74
11¾	2.47	4.94	7.42	9.89	12.37	14.84	17.31	19.78	24.73	29.69	34.63	39.56
12	2.52	5.05	7.58	10.10	12.64	15.16	17.68	20.20	25.26	30.32	35.36	40.40

WEIGHT OF WROUGHT IRON.

TRAUTWINE.

Thickness or Diameter in Inches.	in decimals, of a foot.	Weight of a Square Foot. Lbs.	Weight per foot Square Bar. Lbs.	Weight per foot Round Bar. Lbs.
1/32	.0026	1.263	.0033	.0026
1/16	.0052	2.526	.0132	.0104
3/32	.0078	3.789	.0296	.0233
1/8	.0104	5.052	.0526	.0414
5/32	.0130	6.315	.0823	.0646
3/16	.0156	7.578	.1184	.0930
7/32	.0182	8.841	.1612	.1266
1/4	.0208	10.10	.2105	.1653
9/32	.0234	11.37	.2665	.2093
5/16	.0260	12.63	.3290	.2583
11/32	.0287	13.89	.3980	.3126
3/8	.0313	15.16	.4736	.3720
13/32	.0339	16.42	.5558	.4365
7/16	.0365	17.68	.6446	.5063
15/32	.0391	18.95	.7400	.5813
1/2	.0417	20.21	.8420	.6613
9/16	.0469	22.73	1.066	.8370
5/8	.0521	25.26	1.316	1.033
11/16	.0573	27.79	1.592	1.250
3/4	.0625	30.31	1.895	1.488
13/16	.0677	32.84	2.223	1.746
7/8	.0729	35.37	2.579	2.025
15/16	.0781	37.89	2.960	2.325
1	.0833	40.42	3.368	2.645
1/16	.0885	42.94	3.803	2.986
1/8	.0938	45.47	4.263	3.348
3/16	.0990	48.00	4.750	3.730
1/4	.1042	50.52	5.263	4.133
5/16	.1094	53.05	5.802	4.557
3/8	.1146	55.57	6.368	5.001
7/16	.1198	58.10	6.960	5.466
1/2	.1250	60.63	7.578	5.952
5/8	.1354	65.68	8.893	6.985
3/4	.1458	70.73	10.31	8.101
7/8	.1563	75.78	11.84	9.300
2	.1667	80.83	13.47	10.58
1/8	.1771	85.89	15.21	11.95
1/4	.1875	90.94	17.05	13.39
3/8	.1979	95.99	19.00	14.92
1/2	.2083	101.0	21.05	16.53
5/8	.2188	106.1	23.21	18.23
3/4	.2292	111.2	25.47	20.01
7/8	.2396	116.2	27.84	21.87
3	.2500	121.3	30.31	23.81

WEIGHT OF WROUGHT IRON.

TRAUTWINE.

Thickness or Diameter in Inches	in decimals, of a foot.	Weight of a Square Foot. Lbs.	Weight per foot Square Bar. Lbs.	Weight per foot Round Bars. Lbs.
3 1/8	.2604	126.3	32.89	25.83
1/4	.2708	131.4	35.57	27.94
3/8	.2813	136.4	38.37	30.13
1/2	.2917	141.5	41.26	32.41
5/8	.3021	146.5	44.26	34.76
3/4	.3125	151.6	47.37	37.20
7/8	.3229	156.6	50.57	39.72
4	.3333	161.7	53.89	42.33
1/8	.3438	166.7	57.31	45.01
1/4	.3542	171.8	60.84	47.78
3/8	.3646	176.8	64.47	50.63
1/2	.3750	181.9	68.20	53.57
5/8	.3854	186.9	72.05	56.59
3/4	.3958	192.0	75.99	59.69
7/8	.4063	197.0	80.05	62.87
5	.4167	202.1	84.20	66.13
1/8	.4271	207.1	88.47	69.48
1/4	.4375	212.2	92.83	72.91
3/8	.4479	217.2	97.31	76.43
1/2	.4583	222.3	101.9	80.02
5/8	.4688	227.3	106.6	83.70
3/4	.4792	232.4	111.4	87.46
7/8	.4896	237.5	116.3	91.31
6	.5000	242.5	121.3	95.23
1/4	.5208	252.6	131.6	103.3
1/2	.5417	262.7	142.3	111.8
3/4	.5625	272.8	153.5	120.5
7	.5833	282.9	165.0	129.6
1/4	.6042	293.0	177.0	139.0
1/2	.6250	303.1	189.5	148.8
3/4	.6458	313.2	202.3	158.9
8	.6667	323.3	215.6	169.3
1/4	.6875	333.4	229.3	180.1
1/2	.7083	343.5	243.4	191.1
3/4	.7292	353.6	247.9	202.5
9	.7500	363.8	272.8	214.3
1/4	.7708	373.9	288.2	226.3
1/2	.7917	384.0	304.0	238.7
3/4	.8125	394.1	320.2	251.5
10	.8333	404.2	336.8	264.5
1/2	.8750	424.4	371.3	291.6
11	.9167	444.6	407.5	320.1
1/2	.9583	464.8	445.4	349.8
12	1 Foot.	485.	485.	380.9

WEIGHT OF ROLLED LEAD, COPPER AND BRASS.—SHEET AND BAR.

Thickness or Diameter in inches.	LEAD.			COPPER.			BRASS.			Thickness or Diameter in inches.
	Sheets per Square Foot.	Square Bars 1 foot long.	Round Bars 1 foot long.	Sheets per Square Foot.	Square Bars 1 foot long.	Round Bars 1 foot long.	Sheets per Square Foot.	Square Bars 1 foot long.	Round Bars 1 foot long.	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
1-32	1.86	.005	.004	1.44	.004	.003	1.36	.004	.003	1-32
1-16	3.72	.019	.015	2.89	.015	.012	2.71	.014	.011	1-16
3-32	5.58	.044	.034	4.33	.034	.027	4.06	.032	.025	3-32
⅛	7.44	.078	.061	5.77	.060	.047	5.42	.056	.044	⅛
5-32	9.30	.121	.095	7.20	.094	.074	6.75	.088	.069	5-32
3-16	11.2	.174	.137	8.66	.135	.106	8 13	.127	.100	3-16
7-32	13.0	.237	.187	10.1	.184	.144	9.50	.173	.136	7-32
¼	14.9	.310	.244	11.5	.240	.189	10.8	.226	.177	¼
5-16	18.6	.485	.381	14.4	.376	.295	13.5	.353	.277	5-16
⅜	22.3	.698	.548	17.3	.541	.425	16.3	.508	.399	⅜
7-16	26.0	.950	.746	20.2	.736	.578	19.0	.691	.543	7-16
½	29.8	1.24	.974	23.1	.962	.755	21.7	.903	.709	½
9-16	33.5	1.57	1.23	26.0	1.22	.955	24.3	1.14	.900	9-16
⅝	37.2	1.94	1.52	28.9	1.50	1.18	27.1	1.41	1.11	⅝
11-16	40.9	2.34	1.84	31.7	1.82	1.43	29.8	1.70	1.34	11-16
¾	44.6	2.79	2.19	34.6	2.16	1.70	32.5	2.03	1.60	¾
13-16	48.3	3.27	2.57	37.5	2.55	1.99	35.2	2.38	1.87	13-16
⅞	52.1	3.80	2.98	40.4	2.94	2.31	37.9	2.76	2.17	⅞
15-16	56.0	4.37	3.42	43.3	3.38	2.65	40.6	3.18	2.49	15-16
1.	59.5	4.96	3.90	46.2	3.85	3.02	43.3	3.61	2.84	1.
1⅛	66.9	6.27	4.92	52.0	4.87	3.82	48.7	4.57	3.60	1⅛
1¼	74.4	7.75	6.09	57.7	6.01	4.72	54.2	5.64	4.43	1¼
1⅜	81.8	9.37	7.37	63.5	7.28	5.72	59.6	6 82	5.37	1⅜
1½	89.3	11.2	8.77	69.3	8.65	6.80	65.0	8.12	6.38	1½
1⅝	96.7	13.1	10.3	75.1	10.2	7.98	70.4	9.53	7.49	1⅝
1¾	104.	15.2	11.9	80.8	11.8	9.25	75.9	11.1	8.68	1¾
1⅞	112.	17.5	13.7	86.6	13.5	10.6	81.3	12.7	9.97	1⅞
2.	119.	19.8	15.6	92.3	15.4	12.1	86.7	14.4	11.3	2.

WIRE,

IRON, STEEL, COPPER, BRASS.

Weight of 100 Feet in Pounds.

BIRMINGHAM WIRE GUAGE.

No. of Gauge.	Per Lineal Foot.			
	Iron.	Steel.	Copper.	Brass.
0000	54.62	55.13	62.39	58.93
000	47.86	48.32	54.67	51.64
00	38.27	38.63	43.71	41.28
0	30.63	30.92	34.99	33.05
1	23.85	24.07	27.24	25.73
2	21.37	21.57	24.41	23.06
3	17.78	17.94	20.3	19.18
4	15.01	15.15	17.15	16.19
5	12.82	12.95	14.65	13.84
6	10.92	11.02	12.47	11.78
7	8.586	8.667	9.807	9.263
8	7.214	7.283	8.241	7.783
9	5.805	5.859	6.63	6.262
10	4.758	4.803	5.435	5.133
11	3.816	3.852	4.359	4.117
12	3.148	3.178	3.596	3,397
13	2.392	2.414	2.732	2.58
14	1.826	1.843	2.085	1.969
15	1.374	1.387	1.569	1.482
16	1.119	1.13	1.279	1.208
17	.8915	.9	1.018	.9618
18	.6363	.6423	.7268	.6864
19	.4675	.472	.534	.5043
20	.3246	.3277	.3709	.3502
21	.2714	.274	.31	.2929
22	.2079	.2098	.2373	.2241
23	.1656	.1672	.1892	.1788
24	.1283	.1295	.1465	.1384
25	.106	.107	.1211	.1144
26	.0859	.0867	.0981	.0926
27	.0678	.0685	.0775	.0732
28	.0519	.0524	.0593	.056
29	.0448	.0452	.0511	.0483
30	.0382	.0385	.0436	.0412
31	.0265	.0267	.0303	.0286
32	.0215	.0217	.0245	.0231
33	.017	.0171	.0194	.0183
34	.013	.0131	.0148	.014
35	.0066	.0067	.0076	.0071
36	.0042	.0043	.0048	.0046

GALVANIZED AND BLACK IRON.

Weight in Pounds per Square Foot of Galvanized Sheet Iron, both Flat and Corrugated.

The numbers and thicknesses are those of the iron before it is galvanized. When a flat sheet (the ordinary size of which is from 2 to 2½ feet in width, by 6 to 8 feet in length) is converted into a corrugated one, with corrugations 5 inches wide from center to center, and about an inch deep (the common sizes), its width is thereby reduced about $\frac{1}{10}$th part, or from 30 to 27 inches; and consequently the weight per square foot of area covered is increased about $\frac{1}{9}$th part. When the corrugated sheets are laid upon a roof, the overlapping of about 2½ inches along their sides, and of 4 inches along their ends, diminishes the covered area about $\frac{1}{7}$th part more; making their weight per square foot of roof about $\frac{1}{6}$th part greater than before. Or the weight of corrugated iron per square foot in place on a roof, is about $\frac{1}{3}$ greater than that of the flat sheets of above sizes of which it is made.

Number by Birmingham Wire Gauge.	BLACK.		GALVANIZED.		
	Thickness in inches.	Flat. Lbs.	Flat. Lbs.	Corrugated. Lbs.	Cor. on Roof. Lbs.
30	.012	.485	.806	.896	1.08
29	.013	.526	.857	.952	1.14
28	.014	.565	.897	.997	1.20
27	.016	.646	.978	1.09	1.30
26	.018	.722	1.06	1.18	1.41
25	.020	.808	1.14	1.27	1.52
24	.022	.889	1.22	1.36	1.62
23	.025	1.01	1.34	1.49	1.79
22	.028	1.13	1.46	1.62	1.95
21	.032	1.29	1.63	1.81	2.17
20	.035	1.41	1.75	1 94	2.33
19	.042	1.69	2.03	2.26	2.71
18	.049	1.98	2.32	2.58	3.09
17	.058	2.34	2.68	2.98	3.57
16	.065	2.63	2.96	3.29	3.95
15	.072	2.91	3.25	3.61	4.33
14	.083	3.36	3.69	4.10	4.92
13	.095	3.84	4.18	4.64	5.57

NOTE.—The galvanizing of sheet iron adds about one-third of a pound to its weight per square foot.

ROOFING SLATE.

General Rule for the Computation of Slate.

From the length of the Slate take three inches, or as many as the third covers the first; divide the remainder by 2, and multiply the quotient by the width of the slate, and the product will be the number of square inches in a single slate. Divide the number of square inches thus procured by 144, the number of square inches in square foot, and the quotient will be the number of feet and inches required. A square of slate is what will cover 100 feet square, when laid upon the roof.

Weight per Cubic Foot, - 174 Pounds.

Weight per Square Foot.

Thickness,	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1 inch.
Weight,	1.81	2.71	3.62	5.43	7.25	9.06	10.87	14.5 lbs.

Table of Sizes and Number of Slate in One Square.

Size in Inches.	No. of Slate in Square.	Size in Inches.	No. of Slate in Square.	Size in Inches.	No. of Slate in Square.
6 × 12	53	8 × 16	277	12 × 20	141
7 12	457	9 16	246	14 20	121
8 12	400	10 16	221	11 22	137
9 12	355	12 16	184	12 22	126
10 12	320	9 18	213	14 22	108
12 12	266	10 18	192	12 24	114
7 14	374	11 18	174	14 24	98
8 14	327	12 18	160	16 24	86
9 14	291	14 18	137	14 26	89
10 14	261	10 20	169	16 26	78
12 14	218	11 20	154		

CAPACITY OF CISTERN,

IN GALLONS, FOR EACH FOOT IN DEPTH.

Diameter in feet.	Gallons.	Diameter in feet.	Gallons.
2.	23.5	9.	475.87
2.5	36.7	9.5	553.67
3.	52.9	10.	587.5
3.5	71.96	11.	710.9
4.	94.02	12.	846.4
4.5	119.	13.	992.9
5.	146.8	14.	1,151.5
5.5	177.7	15.	1,321.9
6.	211.6	20.	2,350.0
6.5	248.22	25.	3,570.7
7.	287.84	30.	5,287.7
7.5	330.48	35.	7,189.
8.	376.	40.	9,367.2
8.5	424.44	45.	11,893.2

The American standard gallon contains 231 cubic inches, or 8⅓ pounds of pure water. A cubic foot contains 62.3 pounds of water, or 7.48 gallons. Pressure per square inch is equal to the depth or head in feet multiplied by .433. Each 27.72 inches of depth gives a pressure of one pound to the square inch.

SKYLIGHT AND FLOOR GLASS.

LENNOX PLATE GLASS CO., - WARD & CO., AGENTS, PHILADELPHIA.

Weight per Cubic Foot, - 156 Pounds.

Weight per Square Foot.

Thickness,	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1 inch.
Weight,	1.62	2.43	3.25	4.88	6.50	8.13	9.75	13 lbs.

FLAGGING.

Weight per Cubic Foot, - 168 Pounds.

Weight per Square Foot.

Thickness,	1	2	3	4	5	6	7	8 inch.
Weight,	14	28	42	56	70	84	98	112 lbs.

AMERICAN AND BIRMINGHAM WIRE GAUGES.

Thickness in Inches.

HASWELL.

No. Gauge.	Thickness American Gauge.	Thickness Birmingh'm Gauge.	No. Gauge.	Thickness American Gauge.	Thickness Birmingh'm Gauge.	No. Gauge.	Thickness American Gauge.	Thickness Birmingh'm Gauge.
	Inch.	Inch.		Inch.	Inch.		Inch.	Inch.
0000	.46	.454	11	.0907	.12	25	.0179	.02
000	.4096	.425	12	.0808	.109	26	.0160	.018
00	.3648	.38	13	.0719	.095	27	.0142	.016
0	.3248	.34	14	.0641	.083	28	.0126	.014
1	.2893	.30	15	.057	.072	29	.0112	.013
2	.2576	.284	16	.0508	.065	30	.01	.012
3	.2294	.259	17	.0452	.058	31	.0089	.01
4	.2043	.238	18	.0403	.049	32	.0079	.009
5	.1819	.22	19	.0359	.042	33	.007	.008
6	.1620	.203	20	.0319	.035	34	.0063	.007
7	.1443	.18	21	.0284	.032	35	.0056	.005
8	.1285	.165	22	.0253	.028	36	.005	.004
9	.1144	.148	23	.0225	.025			
10	.1019	.134	24	.0201	.022			

RAILROAD SPIKES.

Length and Thickness in a Keg of 150 Pounds.

Length.	Thickness.	No.	Length.	Thickness.	No.
$4\frac{1}{2}$	$\frac{7}{16}$	527	$5\frac{1}{2}$	$\frac{1}{2}$	356
$4\frac{1}{2}$	$\frac{1}{2}$	400	$5\frac{1}{2}$	$\frac{9}{16}$	290
5	$\frac{5}{8}$	710	$5\frac{1}{2}$	$\frac{5}{8}$	219
5	$\frac{7}{16}$	489	6	$\frac{1}{2}$	311
5	$\frac{1}{2}$	390	6	$\frac{9}{16}$	263
5	$\frac{9}{16}$	296	6	$\frac{5}{8}$	197
5	$\frac{5}{8}$	258			

SPLICES AND BOLTS

For One Mile of Track.

Rails 30 feet long take 704 splices, 1408 bolts.

" 28 " " 754 " 1508 "

" 27 " " 782 " 1564 "

" 25 " " 844 " 1688 "

" 24 " " 880 " 1760 "

IRON RIVETS.

Weight per 100.

Length Under Head.	Diameters.						
	¼	⅜	½	⅝	¾	⅞	1
1	1.895	4.848	9.66	16.79	26.49	39.3	55.2
⅛	2.067	5.235	10.34	17.86	27.99	41.4	57.9
¼	2.238	5.616	11.04	18.96	29.61	43.5	60.7
⅜	2.410	6.003	11.73	20.03	31.13	45.6	63.4
½	2.582	6.402	12.43	21.04	32.74	47.8	66.2
⅝	2.754	6.789	13.12	22.11	34.25	49.9	68.9
¾	2.926	7.179	13.81	23.21	35.86	52.0	71.7
⅞	3.098	7.566	14.50	24.28	37.37	54.1	74.4
2	3.269	7.956	15.19	25.48	38.99	56.3	77.2
⅛	3.441	8.343	15.88	26.56	40.40	58.4	79.9
¼	3.613	8.733	16.57	27.65	42.11	60.5	82.7
⅜	3.785	9.120	17.26	28.73	43.67	62.6	85.4
½	3.957	9.511	17.95	29.82	45.24	64.8	88.2
⅝	4.129	9.898	18.64	30.90	46.80	66.9	90.9
¾	4.301	10.29	19.33	31.99	48.36	69.0	93.7
⅞	4.473	10.67	20.02	33.08	49.92	71.1	96.4
3	4.644	11.06	20.71	34.18	51.49	73.3	99.2
⅛	4.816	11.44	21.40	35.27	53.05	75.4	101.9
¼	4.988	11.84	22.09	36.35	54.61	77.5	104.7
⅜	5.160	12.23	22.78	37.44	56.17	79.6	107.4
½	5.332	12.62	23.48	38.52	57.74	81.8	110.2
⅝	5.504	13.01	24.17	39.60	59.30	83.9	112.9
¾	5.676	13.39	24.86	40.69	60.86	86.0	116.7
⅞	5.848	13.78	25.55	41.78	62.42	88.1	119.4
4	6.019	14.17	26.24	42.87	63.99	90.3	121.2
⅛	6.191	14.56	26.93	43.94	65.55	92.4	123.9
¼	6.363	14.95	27.62	45.01	67.11	94.5	126.6
100 Heads.	.519	1.74	4.14	8.10	13.99	22.27	33.15

Length of Rivet required to make one Head = 1½ diameters of Round Bar.

NAILS AND SPIKES.

Size, Length and Number to the Pound.

CUMBERLAND NAIL AND IRON CO.

Ordinary.

Size.	Length.	No. to Lb.
	"	
2d	7/8	716
3 fine	1 1/16	588
3	1 1/16	448
4	1 3/8	336
5	1 3/4	216
6	2	166
7	2 1/4	118
8	2 1/2	94
10	2 3/4	72
12	3 1/8	50
20	3 3/4	32
30	4 1/4	20
40	4 3/4	17
50	5	14
60	5 1/2	10

Light.

	"	
4d	1 3/8	373
5	1 3/4	272
6	2	196

Brads.

	"	
6d	2	163
8	2 1/2	96
10	2 3/4	74
12	3 1/8	50

Clinch.

Length.	No. to Lb.
"	
2	152
2 1/4	133
2 1/2	92
2 3/4	72
3	60
3 1/4	43

Fence.

"	
2	96
2 1/4	66
2 1/2	56
2 3/4	50
3	40

Spikes.

"	
3 1/2	19
4	15
4 1/2	13
5	10
5 1/2	9
6	7

Boat.

"	
1 1/2	206

Finishing.

Size.	Length	No. to Lb.
	"	
4d	1 3/8	384
5	1 3/4	256
6	2	204
8	2 1/2	102
10	3	80
12	3 5/8	65
20	3 7/8	46

Core.

	"	
6d	2	143
8	2 1/2	68
10	2 1/3	60
12	3 1/8	42
20	3 3/4	25
30	4 1/4	18
40	4 3/4	14
W H	2 1/2	69
W H L	2 1/4	72

Slate.

	"	
3d	1 5/16	288
4	1 7/16	244
5	1 3/4	187
6	2	146

TACKS.

Size.	Length.	Number to Pound.	Size.	Length	Number to Pound.	Size.	Length.	Number to Pound.
1 oz.	1/8	16000	4 oz.	7/16	4000	14 oz.	13/16	1143
1 1/2	3/16	10666	6	9/16	2666	16	7/8	1000
2	1/4	8000	8	5/8	2000	18	15/16	888
2 1/2	5/16	6400	10	11/16	1600	20	1	800
3	3/8	5333	12	3/4	1333	22	1 1/16	727

FRANKLIN INSTITUTE

STANDARD SIZES

SQUARE AND HEXAGON NUTS.

Number of each size in 100 lbs.

THESE NUTS ARE CHAMFERED AND TRIMMED.

HOOPES & TOWNSEND, PHILADELPHIA.

Width.	Thickn'ss.	Hole.	Size of Bolt.	Number of Square.	Number of Hexagon.
1/2	1/4	13/64	1/4	8140	9300
19/32	5/16	1/4	5/16	3000	6200
11/16	3/8	5/16	3/8	2320	3120
25/32	7/16	11/32	7/16	1940	2200
7/8	1/2	13/32	1/2	1180	1350
31/32	9/16	29/64	9/16	920	1000
1 1/16	5/8	33/64	5/8	738	830
1 1/4	3/4	5/8	3/4	420	488
1 7/16	7/8	23/32	7/8	280	309
1 5/8	1	27/32	1	180	216
1 13/16	1 1/8	15/16	1 1/8	130	148
2	1 1/4	1 1/16	1 1/4	96	111
2 3/16	1 3/8	1 5/32	1 3/8	70	85
2 3/8	1 1/2	1 9/32	1 1/2	60	70

HEXAGON NUTS.

REGULAR SIZES.

Width.	Thickness.	Hole.	Size of Bolt.	Number in 100 lbs.
1/2	1/4	7/32	1/4	8600
25/32	5/16	17/64	5/16	4260
15/16	3/8	21/64	3/8	2500
1 3/32	7/16	3/8	7/16	2180
1	9/16	7/16	1/2	900
1	9/16	15/32	9/16	880
1 1/8	3/4	17/32	1/2	535
1 3/8	7/8	21/32	3/4	295
1 1/2	1	3/4	7/8	224
1 3/4	1 1/8	27/32	1	150
2	1 3/8	1 5/16	1 1/8	100
2	1 1/2	1 1/16	1 1/4	96
2 1/4	1 3/4	1 3/16	1 3/8	72
2 3/4	1 7/8	1 5/16	1 1/2	43

SQUARE NUTS.

REGULAR SIZES.

Width.	Thickness.	Hole.	Size of Bolt.	Number in 100 lbs.
1/2	1/4	7/32	1/4	6680
25/32	5/16	17/64	5/16	3540
15/16	3/8	21/64	3/8	2050
1 3/32	7/16	3/8	7/16	1380
1	9/16	7/16	1/2	840
1	9/16	15/32	9/16	650
1 1/8	3/4	17/32	1/2	410
1 3/8	7/8	21/32	3/4	270
1 1/2	1	3/4	7/8	215
1 3/4	1 1/8	27/32	1	140
2	1 3/8	1 5/16	1 1/8	95
2 1/4	1 1/4	1 1/16	1 1/4	72
2 1/2	1 1/2	1 3/16	1 3/8	45
3	1 1/2	1 5/16	1 1/2	32

BOLTS.

WITH SQUARE HEADS AND NUTS.

Weight of 100 of the Enumerated Sizes.

HOOPES & TOWNSEND, PHILADELPHIA.

Lengths	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.
Inch.								
1½	4.16	10.62	23.87	39.31				
1¾	4.22	11.72	25.06	41.38				
2	4.75	12.38	26.44	45.69	73.62			
2¼	5.34	12.90	28.62	49.50	76.			
2½	5.97	14.69	29.50	51.25	79.75			
2¾	6.50	16.47	31.16	53.	83.			
3		17.87	32.44	56.	85.38	127.25		
3½		18.94	39.75	63.12	93.44	140.56		
4		20.59	42.50	74.87	108.12	148.37	228.	296.
4½		21.69	44.87	79.62	113.12	158.76	239.	310.
5		23.62	48.81	83.	122.	167.25	250.	324.
5½		25.81	51.38	87.88	128.62	174.88	261.	338.
6		26.87	53.31	92.38	131.75	204.25	272.	352.
6½			56.87	96.88	139.56	214.69	283.	366.
7			59.12	99.87	145.50	228.44	294.	370.
7½			61.87	105.75	150.88	235.31	305.	384.
8			64.44	109.50	157.12	239.88	316.	398.
9			70.50	118.12	169.62	258.12	338.	426.
10			77.	128.13	184.	276.18	360.	454.
11			82.88	136.19	195.13	295.69	382.	482.
12			86.37	144.87	209.75	311.94	404.	510.
13			92.	155.50	219.37	335.81	426.	538.
14			97.75	163.58	237.50	351.88	448.	566.
15			103.25	170.75	249.06	391.75	470.	594.

STANDARD SIZES OF WASHERS.

Number in 100 Lbs.

Diameter.	Size of Hole.	Thickness Wire Gauge.	Size of Bolt.	Number in 100 lbs.
Inch.	Inch.	No.	Inch.	
$\frac{5}{8}$	$\frac{5}{16}$	16	$\frac{1}{4}$	29300
$\frac{3}{4}$	$\frac{3}{8}$	16	$\frac{5}{16}$	18000
1	$\frac{7}{16}$	14	$\frac{3}{8}$	7600
$1\frac{1}{2}$	$\frac{9}{16}$	11	$\frac{1}{2}$	3300
$1\frac{1}{2}$	$\frac{5}{8}$	11	$\frac{9}{16}$	2180
$1\frac{1}{2}$	$\frac{11}{16}$	11	$\frac{5}{8}$	2350
$1\frac{3}{4}$	$\frac{13}{16}$	11	$\frac{3}{4}$	1680
2	$\frac{15}{16}$	10	$\frac{7}{8}$	1140
$2\frac{1}{2}$	$1\frac{1}{8}$	8	1	580
$2\frac{3}{4}$	$1\frac{1}{4}$	8	$1\frac{1}{8}$	470
3	$1\frac{3}{8}$	7	$1\frac{1}{4}$	360
3	$1\frac{1}{2}$	6	$1\frac{3}{8}$	360

WROUGHT IRON WELDED TUBES, FOR STEAM, GAS OR WATER.

1¼ inch and below, Butt Welded; proved to 800 lbs. per square inch, Hydraulic Pressure.
1½ inch and above, Lap " " 500 " " " " "

TABLE OF STANDARD SIZES.—MORRIS, TASKER & CO.

Inside Diameter	Actual Inside Diameter.	Actual Outside Diameter.	Thickness.	Internal Circumference.	External Circumference.	Length of Pipe per □ foot inside surface.	Length of Pipe per □ foot outside surface.	Internal Area.	External Area.	Length of Pipe containing 1 cubic foot.	Weight per foot of length.	No. of Threads per inch of Screw
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Feet.	Feet.	Inches.	Inches.	Feet.	Lbs.	
⅛	.270	.405	.068	.848	1.272	14.15	9.44	.0572	.129	2500.	.243	27
¼	.364	.54	.088	1.144	1.696	10.50	7.075	.1041	.229	1385.	.422	18
⅜	.494	.675	.091	1.552	2.121	7.67	5.657	.1916	.358	751.5	.561	18
½	.623	.84	.109	1.957	2.652	6.13	4.502	.3048	.554	472.4	.845	14
¾	.824	1.05	.113	2.589	3.299	4.635	3.637	.5333	.866	270.	1.126	14
1	1.048	1.315	.134	3.292	4.134	3.679	2.903	.8627	1.357	166.9	1.670	11½
1¼	1.380	1.66	.140	4.335	5.215	2.768	2.301	1.496	3.164	96.25	2.258	11½
1½	1.611	1.9	.145	5.061	5.969	2.371	2.01	2.038	2.835	70.65	2.694	11½
2	2.067	2.375	.154	6.494	7.461	1.848	1.611	3.355	4.430	42.36	3.667	11½
2½	2.468	2.875	.204	7.754	9.032	1.547	1.328	4.783	6.491	30.11	5.773	8
3	3.067	3.5	.217	9.636	11.996	1.245	1.091	7.388	9.621	19.49	7.547	8
3½	3.548	4.	.226	11.146	12.566	1.077	.955	9.887	12.566	14.56	9.055	8
4	4.026	4.5	.237	12.648	14.137	.949	.849	12.730	15.904	11.31	10.728	8
4½	4.508	5.	.247	14.153	15.708	.848	.765	15.939	19.635	9.03	12.492	8
5	5.045	5.563	.259	15.849	17.475	.757	.629	19.990	24.299	7.20	14.564	8
6	6.065	6.625	.280	19.054	20.813	.63	.577	28.889	34.471	4.98	18.767	8
7	7.023	7.625	.301	22.063	23.954	.544	.505	38.737	45.663	3.72	23.410	8
8	7.982	8.625	.322	25.076	27.096	.478	.444	50.039	58.426	2.88	28.348	8
9	9.001	9.688	.344	28.277	30.433	.425	.394	63.633	73.715	2.26	34.077	8
10	10.019	10.75	.366	31.475	33.772	.381	.355	78.838	90.762	1.80	40.641	8

LAP WELDED
AMERICAN CHARCOAL IRON BOILER TUBES.

TABLES OF STANDARD SIZES.

MORRIS, TASKER & CO.

External Diameter.	Internal Diameter.	Thickness.	External Circumference.	Internal Circumference.	Length of Pipe per □ foot inside surface.	Length of Pipe per □ foot outside surface.	Internal Area.	External Area.	Weight per foot.
Inch	Inch	Inch	Inch	Inch	Feet	Feet	Inch	Inch	Lbs.
1	0.856	0.072	3.142	2.689	4.460	3.819	0.575	0.785	0.708
1¼	1.106	0.072	3.927	3.474	3.455	3.056	0.960	1.227	0.9
1½	1.334	0.083	4.712	4.191	2.863	2.547	1.396	1.767	1.250
1¾	1.560	0.095	5.498	4.901	2.448	2.183	1.911	2.405	1.665
2	1.804	0.098	6.283	5.667	2.118	1.909	2.556	3.142	1.981
2¼	2.054	0.098	7.069	6.484	1.850	1.698	3.314	3.976	2.238
2½	2.283	0.109	7.854	7.172	1.673	1.528	4.094	4.909	2.755
2¾	2.533	0.109	8.639	7.957	1.508	1.390	5.039	5.940	3.045
3	2.783	0.109	9.425	8.743	1.373	1.273	6.083	7.069	3.333
3¼	3.012	0.119	10.210	9.462	1.268	1.175	7.125	8.296	3.958
3½	3.262	0.119	10.995	10.248	1.171	1.091	8.357	9.621	4.272
3¾	3.512	0.119	11.781	11.033	1.088	1.018	9.687	11.045	4.590
4	3.741	0.130	12.566	11.753	1.023	0.955	10.992	12.566	5.320
4½	4.241	0.130	14.137	13.323	0.901	0.849	14.126	15.904	6.010
5	4.72	0.140	15.708	14.818	0.809	0.764	17.497	19.635	7.226
6	5.699	0.151	18.849	17.904	0.670	0.637	25.509	28.274	9.346
7	6.657	0.172	21.991	20.914	0.574	0.545	34.805	38.484	12.435
8	7.636	0.182	25.132	23.989	0.500	0.478	45.795	50.265	15.109
9	8.615	0.193	28.274	27.055	0.444	0.424	58.291	63.617	18.002
10	9.573	0.214	31.416	30.074	0.399	0.382	71.975	78.540	22.19

WROUGHT IRON WELDED TUBES.

EXTRA STRONG.

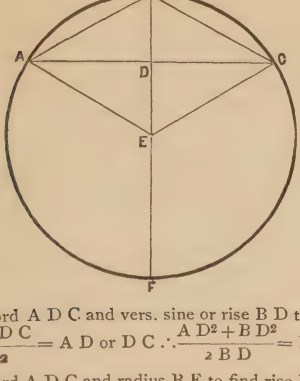
Nominal Diameter.	Actual Outside Diameter.	Thickness. Extra Strong.	Thickness. Double Extra Strong.	Actual Inside Diameter. Extra Strong	Actual Inside Diam. Double Extra Strong
⅛	.405	.100		.205	
¼	.54	.123		.294	
⅜	.675	.127		.421	
½	.84	.149	.298	.542	.244
¾	1.05	.157	.314	.736	.422
1	1.315	.182	.364	.951	.587
1¼	1.66	.194	.388	1.272	.884
1½	1.9	.203	.406	1.494	1.088
2	2.375	.221	.442	1.933	1.491
2½	2.875	.280	.560	2.315	1.755
3	3.5	.304	.608	2.892	2.284
3½	4.	.321	.642	3.358	2.716
4	4.5	.341	.682	3.818	3.136

WINDOW GLASS.

Number of Lights per Box of 50 Feet.

Inches.	No.	Inches.	No.	Inches.	No.	Inches.	No.
6×8	150	12×18	33	16×44	10	26×32	9
7 9	115	12 20	30	18 20	20	26 34	8
8 10	90	12 22	27	18 22	18	26 36	8
8 11	82	12 24	25	18 24	17	26 40	7
8 12	75	12 26	23	18 26	15	26 42	7
8 13	70	12 28	21	18 28	14	26 44	6
8 14	64	12 30	20	18 30	13	26 48	6
8 15	60	12 32	18	18 32	13	26 50	6
8 16	55	12 34	17	18 34	12	26 54	5
9 11	72	13 14	40	18 36	11	26 58	5
9 12	67	13 16	35	18 38	11	28 30	9
9 13	62	13 18	31	18 40	10	28 32	8
9 14	57	13 20	28	18 44	9	28 34	8
9 15	53	13 22	25	20 22	16	28 36	7
9 16	50	13 24	23	20 24	15	28 38	7
9 17	47	13 26	21	20 26	14	28 40	6
9 18	44	13 28	19	20 28	13	28 44	6
9 20	40	13 30	18	20 30	12	28 46	6
10 12	60	14 16	32	20 32	11	28 50	5
10 13	55	14 18	29	20 34	11	28 52	5
10 14	52	14 20	26	20 36	10	28 56	4
10 15	48	14 22	23	20 38	9	30 36	7
10 16	45	14 24	22	20 40	9	30 40	6
10 17	42	14 26	20	20 44	8	30 42	6
10 18	40	14 28	18	20 46	8	30 44	5
10 20	36	14 30	17	20 48	8	30 46	5
10 22	33	14 32	16	20 50	7	30 48	5
10 24	30	14 34	15	20 60	6	30 50	5
10 26	28	14 36	14	22 24	14	30 54	4
10 28	26	14 40	13	22 26	13	30 56	4
10 30	24	14 44	11	22 28	12	30 60	4
10 32	22	15 18	27	22 30	11	32 42	5
10 34	21	15 20	24	22 32	10	32 44	5
11 13	50	15 22	22	22 34	10	32 46	5
11 14	47	15 24	20	22 36	9	32 48	5
11 15	44	15 26	18	22 38	9	32 50	4
11 16	41	15 28	17	22 40	8	32 54	4
11 17	39	15 30	16	22 44	8	32 56	4
11 18	36	15 32	15	22 46	7	32 60	4
11 20	33	16 18	25	22 50	7	34 40	5
11 22	30	16 20	23	24 28	11	34 44	5
11 24	27	16 22	20	24 30	10	34 46	5
11 26	25	16 24	19	24 32	9	34 50	4
11 28	23	16 26	17	24 36	8	34 52	4
11 30	21	16 28	16	24 40	8	34 56	4
11 32	20	16 30	15	24 44	7	36 44	5
11 34	19	16 32	14	24 46	7	36 50	4
12 14	43	16 34	13	24 48	6	36 56	4
12 15	40	16 36	12	24 50	6	36 60	3
12 16	38	16 38	12	24 54	5	36 64	3
12 17	35	16 40	11	24 56	5	40 60	3

PROPERTIES OF CIRCLES



(1.) Given, chord A D C and vers. sine or rise B D to find radius—

$$\frac{A\,D\,C}{2} = A\,D \text{ or } D\,C \therefore \frac{A\,D^2 + B\,D^2}{2\,B\,D} = B\,E$$

(2.) Given, chord A D C and radius B E to find rise B D,

$$B\,E - \sqrt{B\,E^2 - A\,D^2} = B\,D$$

(3.) Given, the radius and rise to find the chord A D C,

$$A\,D = \sqrt{B\,E^2 - (B\,E - B\,D)^2}$$

$$\text{Chord } A\,D\,C = 2\,A\,D = 2\sqrt{B\,E^2 - (B\,E - B\,D)^2}$$

(4.) Given, the chord of an arc and the chord of half the arc to find the length of the arc—

$$\frac{8\,A\,B - A\,D\,C}{3} = \text{arc } A\,B\,C \text{ (very nearly).}$$

(5.) To find the number of degrees in the arc of a circle, when the diameter or radius and the length of the arc are given,

$$\frac{\text{Arc } A\,B\,C}{\pi \times \text{diameter}} \times 360^\circ = \text{degrees in arc } A\,B\,C \qquad \pi = 3.1416$$

or,

$$\frac{\text{Arc } A\,B\,C}{2 \text{ radius} \times \pi} \times 360^\circ = \text{degrees in } A\,B\,C$$

(a.) Circumference of a circle to diameter 1
Surface of a sphere to diameter 1
Area of a circle to radius 1
} $= \pi = 3.1416$

(b.) Area of a circle to diameter 1 = .7854

(c.) Capacity of a sphere to diameter 1 = .5236

(d.) do do to radius 1 = 4.1888

(e.) Length of an arc of one degree = R × .0174533
" " one minute = " .0002909
" " one second = " .0000048

Example.—Let radius = 100 feet and the angle of the arc be 90°,
What is the length of the arc?
100 × .0174533 × 90° = 157.08 feet.

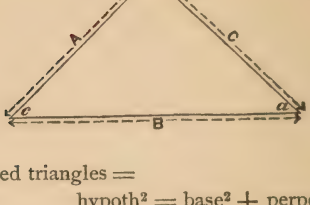
(f.) An acre is 69.5701 yards square; or 4840 square yards.
or 208.710321 feet square; or 43560 square feet.
or 220 feet × 198 feet.

(g.) 1 French metre is 39.3685 inches.

(h.) 1 French kilogramme is 2.204737 lbs.

PROPERTIES OF TRIANGLES.

MOLESWORTH.



In right angled triangles =

$\text{hypoth}^2 = \text{base}^2 + \text{perpend}^2$

$\text{base}^2 = (\text{hyp} + \text{perp}) \times (\text{hyp}—\text{per})$

$\text{perp}^2 = (\text{hy} + \text{ba}) \times (\text{hy}—\text{ba})$

VALUE OF ANY SIDE A.

$$A = \frac{\text{B. sin. } a.}{\text{Sin. } b.} \qquad A = \frac{\text{C. sin. } a.}{\text{Sin. } c.}$$

$$A = \sqrt{B^2 + C^2 - 2\,B\,C \cos. a.}$$

$$A = \frac{B}{\text{Cos. } c. + \text{Sin. } c. \text{ Cot. } a.}$$

$$A = \frac{C}{\text{Cos. } b. + \text{Sin. } b. \text{ Cot. } a.}$$

$$A = \text{B. cos. } c. + \text{B. sin. } c. \text{ Cot. } b.$$

VALUE OF ANY ANGLE.

$$\text{Sin. } b. = \frac{\text{B. sin. } a.}{A} \qquad \text{Sin. } b. = \frac{\text{B. sin. } a.}{C}$$

$$\text{Cos. } b. = \frac{A^2 + C^2 - B^2}{2\,A\,C}$$

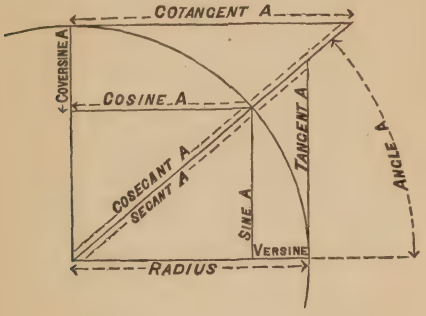
$$\text{Sin. } b. = \text{Sin. } (c. + a.)$$

$$\text{Sin. } b. = \text{Sin. } c. \text{ Cos. } a. + \text{cos. } c. \text{ sin. } a.$$

TRIGONOMETRICAL EXPRESSIONS.

MOLESWORTH.

The diagram shows the different trigonometrical expressions in terms of the angle A.



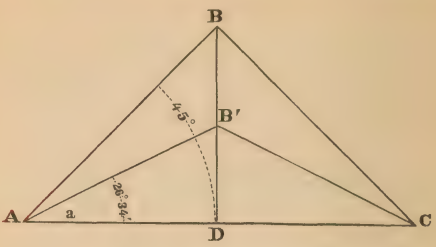
Complement of an angle = its difference from 90°
Supplement..... = its difference from 180°

TRIGONOMETRICAL EQUIVALENTS.

$\sqrt{(1-\text{Sin}^2)} = \text{Cosin}$
$\text{Sin} \div \text{Tan} = \text{Cosin}$
$\text{Sin} \times \text{Cotan} = \text{Cosin}$
$\text{Sine} \div \text{Cos} = \text{Tangent}$
$\text{Cos} \div \text{Sine} = \text{Cotang}$
$\text{Sin}^2 + \text{Cos}^2 = \text{Rad}^2$
$\text{Rad}^2 + \text{Tan}^2 = \text{Secant}^2$
$1 \div \text{Tan} = \text{Cotang}$

$\sqrt{(1-\text{Cosin}^2)} = \text{Sine}$
$\text{Cosin} \div \text{Cotan} = \text{Sine}$
$1 \div \text{Cotan} = \text{Tangent}$
$1 \div \text{Sin} = \text{Cosecant}$
$1 \div \text{Cosin} = \text{Secant}$
$1 \div \text{Cosecant} = \text{Sine}$
$1 \div \text{Secant} = \text{Cosin}$
$\text{Rad}-\text{Cosin} = \text{Versin}$
$\text{Rad}-\text{Sin} = \text{Coversin}$

USE OF TABLE OF NATURAL SINES, &c.



Example 1. To find the angle *a*, when A D & B′ D are given, from table of natural sines and tangents, p. 97.

A D being radius, B′ D = Tan. a. Let $\begin{cases} \text{A D} = 20. \\ \text{B′ D} = 10. \end{cases}$

$$\text{Then } \frac{\text{B′ D}}{\text{A D}} = \frac{10}{20} = .50000;$$

Referring to table we find for

26°, the natural tangent to be	.48773
27°, the natural tangent to be	.50952
Difference, - - -	.02179

The angle, therefore, is more than 26 and less than 27 degrees. If greater accuracy is required, take the difference between natural tangent of 26° and 27° as above, viz.: .02179 and divide by 60 which will give .00036 for one minute. Now subtract from .50000 the natural tangent for 26°, viz.: .48773, leaving .01227, and divide the difference by .00036; the quotient will be 34 minutes. The angle, therefore, is 26° 34′.

Example 2. If A D = 20, and B D = 20, what will be the angle subtended by B D?

$$\frac{\text{B D}}{\text{A D}} = \frac{20}{20} = 1.0000.$$

The natural tangent of 1 is 45°.

NATURAL SINES, &c.

Deg.	Sine.	Cover.	Cosecnt	Tangt.	Cotang.	Secant.	Versin	Cosin.	Deg.
0	.00	1.00000	Infinite.	.0	Infinite.	1 00000	.0	1.00000	90
1	.01745	.98254	57.2986	.01745	57.2899	1.00015	.0001	.99984	89
2	.03489	.96510	28.6537	.03492	28.6362	1.00060	.0006	.99939	88
3	.05233	.94766	19.1073	.05240	19.0811	1.00137	.0013	.99862	87
4	.06975	.93024	14.3355	.06992	14.3006	1.00244	.0024	.99756	86
5	.08715	.91284	11.4737	.08748	11.4300	1.00381	.0038	.99619	85
6	.10452	.89547	9.5667	.10510	9.5143	1.00550	.0054	.99452	84
7	.12186	.87813	8.2055	.12278	8.1443	1.00750	.0074	.99254	83
8	.13917	.86082	7.1852	.14054	7.1153	1.00982	.0097	.99026	82
9	.15643	.84356	6.3924	.15838	6.3137	1.01246	.0123	.98768	81
10	.17364	.82635	5.7587	.17632	5.6712	1.01542	.0151	.98480	80
11	.19080	.80919	5.2408	.19438	5.1445	1.01871	.0183	.98162	79
12	.20791	.79208	4.8097	.21255	4.7046	1.02234	.0218	.97814	78
13	.22495	.77504	4.4454	.23086	4.3314	1.02630	.0256	.97437	77
14	.24192	.75807	4.1335	.24932	4.0107	1.03061	.0297	.97029	76
15	.25881	.74118	3.8637	.26794	3.7320	1.03527	.0340	.96592	75
16	.27563	.72436	3.6279	.28674	3.4874	1.04029	.0387	.96126	74
17	.29237	.70762	3.4203	.30573	3.2708	1.04569	.0436	.95630	73
18	.30901	.69098	3.2360	.32491	3.0776	1.05146	.0489	.95105	72
19	.32556	.67443	3.0715	.34432	2.9042	1.05762	.0544	.94551	71
20	.34202	.65797	2.9238	.36397	2.7474	1.06417	.0603	.93969	70
21	.35836	.64163	2.7904	.38386	2.6050	1.07114	.0664	.93358	69
22	.37460	.62539	2.6694	.40402	2.4750	1.07853	.0728	.92718	68
23	.39073	.60926	2.5593	.42447	2.3558	1.08636	.0794	.92050	67
24	.40673	.59326	2.4585	.44522	2.2460	1.09463	.0864	.91354	66
25	.42261	.57738	2.3662	.46630	2.1445	1.10337	.0936	.90630	65
26	.43837	.56162	2.2811	.48773	2.0503	1.11260	.1012	.89879	64
27	.45399	.54600	2.2026	.50952	1.9626	1.12232	.1089	.89100	63
28	.46947	.53052	2.1300	.53170	1.8807	1.13257	.1170	.88294	62
29	.48480	.51519	2.0626	.55430	1.8040	1.14335	.1253	.87461	61
30	.50000	.50000	2.0000	.57735	1.7320	1.15470	.1339	.86602	60
31	.51503	.48496	1.9416	.60086	1.6642	1.16663	.1428	.85716	59
32	.52991	.47008	1.8870	.62486	1.6003	1.17917	.1519	.84804	58
33	.54463	.45536	1.8360	.64940	1.5398	1.19236	.1613	.83867	57
34	.55919	.44080	1.7882	.67450	1.4825	1.20621	.1709	.82903	56
35	.57357	.42642	1.7434	.70020	1.4281	1.22077	.1808	.81915	55
36	.58778	.41221	1.7013	.72654	1.3763	1.23606	.1909	.80901	54
37	.60181	.39818	1.6616	.75355	1.3270	1.25213	.2013	.79863	53
38	.61566	.38433	1.6242	.78128	1.2799	1.26901	.2119	.78801	52
39	.62932	.37067	1.5890	.80978	1.2348	1.28675	.2228	.77714	51
40	.64278	.35721	1.5557	.83909	1.1917	1.30540	.2339	.76604	50
41	.65605	.34394	1.5242	.86928	1.1503	1.32501	.2452	.75470	49
42	.66913	.33086	1.4944	.90040	1.1106	1.34563	.2568	.74314	48
43	.68199	.31800	1.4662	.93251	1.0723	1.36732	.2686	.73135	47
44	.69465	.30534	1.4395	.96568	1.0355	1.39016	.2806	.71933	46
45	.70710	.29289	1.4142	1.00000	1.0000	1.41421	.2928	.70710	45
	Cosin.	Versin.	Secant.	Cotang.	Tangt.	Cosecnt	Cover.	Sine.	

CIRCUMFERENCES OF CIRCLES

Advancing by Eighths.

CIRCUMFERENCES.

Diam	.0	.⅛	.¼	.⅜	.½	.⅝	.¾	.⅞
0	.0	.3927	.7854	1.178	1.570	1.963	2.356	2.748
1	3.141	3.534	3.927	4.319	4.712	5.105	5.497	5.890
2	6.283	6.675	7.068	7.461	7.854	8.246	8 639	9.032
3	9.424	9.817	10.21	10.60	10.99	11.38	11.78	12.17
4	12.56	12.95	13.35	13.74	14.13	14.52	14.92	15.31
5	15.70	16.10	16.49	16.88	17.27	17.67	18.06	18.45
6	18.84	19.24	19.63	20.02	20.42	20.81	21.20	21.59
7	21.99	22.38	22.77	23.16	23.56	23.95	24.34	24.74
8	25.13	25.52	25.91	26.31	26.70	27.09	27.48	27.88
9	28.27	28.66	29.05	29.45	29.84	30.23	30.63	31.02
10	31.41	31.80	32.20	32.59	32.98	33.37	33.77	34.16
11	34.55	34.95	35.34	35.73	36.12	36.52	36.91	37.30
12	37.69	38.09	38.48	38.87	39.27	39.66	40.05	40.44
13	40 84	41.23	41.62	42.01	42.41	42.80	43.19	43.58
14	43.98	44.37	44.76	45.16	45.55	45.94	46.33	46.73
15	47.12	47.51	47.90	48.30	48.69	49.08	49.48	49.87
16	50.26	50.65	51.05	51.44	51.83	52.22	52.62	53.01
17	53.40	53.79	54.19	54.58	54.97	55.37	55.76	56.15
18	56.54	56.94	57.33	57.72	58.11	58.51	58.90	59.29
19	59.69	60.08	60.47	60.86	61.26	61.65	62.04	62.43
20	62.83	63.22	63.61	64.01	64.40	64.79	65.18	65.58
21	65.97	66.36	66.75	67.15	67.54	67.93	68.32	68.72
22	69.11	69.50	69.90	70.29	70.68	71.07	71.47	71.86
23	72.25	72.64	73.04	73.43	73 82	74 22	74.61	75.00
24	75.39	75.79	76.18	76.57	76.96	77.36	77.75	78.14
25	78.54	78.93	79.32	79.71	80.10	80.50	80.89	81.28
26	81.68	82.07	82.46	82.85	83.25	83.64	84.03	84.43
27	84.82	85.21	85.60	86.00	86.39	86.78	87.17	87.57
28	87.96	88.35	88.75	89.14	89.53	89.92	90.32	90.71
29	91.10	91.49	91.89	92.28	92.67	93.06	93.46	93.85
30	94.24	94.64	95.03	95.42	95.81	96.21	96.60	96.99
31	97.39	97.78	98.17	98.57	98.96	99.35	99.75	100.14
32	100.53	100.92	101.32	101.71	102 10	102.49	102.89	103.29
33	103.67	104.07	104.46	104.85	105.24	105.64	106.03	106.42
34	106.81	107.21	107.60	107.99	108.39	108.78	109.17	109.56
35	109.96	110.35	110.74	111.13	111.53	111.92	112 31	112.71
36	113.10	113.49	113.88	114.28	114.67	115.06	115.45	115.85
37	116.24	116.63	117.02	117.42	117.81	118.20	118.60	118.99
38	119.38	119.77	120.17	120.56	120.95	121.34	121.74	122.13
39	122.52	122.92	123.31	123.70	124.09	124.49	124.88	125.27
40	125.66	126.06	126.45	126.84	127.24	127.63	128.02	128.41
41	128.81	129.20	129.59	129 98	130.38	130.77	131.16	131.55
42	131.95	132.34	132.73	133.13	133.52	133.91	134.30	134.70
43	135.09	135.48	135.87	136.27	136.66	137.05	137.45	137.84
44	138.23	138.62	139.02	139.41	139.80	140.19	140 59	140.98
45	141.37	141.76	142.16	142.55	142.94	143.34	143.73	144.12

AREAS OF CIRCLES,

Advancing by Eighths.

AREAS.

Diam.	.0	.⅛	.¼	.⅜	.½	.⅝	.¾	.⅞
0	.0	.0122	.0490	.1104	.1963	.3068	.4417	.6013
1	.7854	.9940	1.227	1.484	1.767	2.073	2.405	2.761
2	3.1416	3.546	3.976	4.430	4.908	5.411	5.939	64.91
3	7.068	7.669	8.295	8.946	9.621	10.32	11.04	11.79
4	12.56	13.36	14.18	15.03	15.90	16.80	17.72	18.66
5	19.63	20.62	21 64	22.69	23.75	24.85	25.96	27.10
6	28.27	29.46	30.67	31.91	33.18	34.47	35.78	37.12
7	38.48	39.87	41.28	42.71	44.17	45.66	47.17	48.70
8	50.26	51.84	53.45	55.08	56.74	58.42	60.13	61.86
9	63.61	65.39	67.20	69.02	70.88	72.75	74.69	76.58
10	78.54	80 51	82.51	84.54	86.59	88.66	90.76	92.88
11	95.03	97.20	99.40	101.6	103.8	106.1	108.4	110.7
12	113.0	115.4	117.8	120.2	122.7	125.1	127.6	130.1
13	132.7	135.2	137.8	140.5	143.1	145.8	148.4	151.2
14	153.9	156.6	159.4	162.2	165.1	167.9	170.8	173.7
15	176.7	179.6	182.6	185.6	188.6	191.7	194.8	197.9
16	201.0	204.2	207.3	210.5	213.8	217.0	220.3	223.6
17	226.9	230.3	233.7	237.1	240.5	243.9	247.4	250.9
18	254.4	258.0	261.5	265.1	268.8	272.4	276.1	279.8
19	283.5	287.2	291.0	294.8	298 6	302.4	306.3	310.2
20	314.1	318.1	322.0	326.0	330.0	334.1	338.1	342.2
21	346.3	350.4	354 6	358.8	363.0	367.2	371.5	375.8
22	380.1	384.4	388.8	393.2	397.6	402.0	406.4	410.9
23	415.4	420.0	424.5	429.1	433.7	438.3	443.0	447.6
24	452.3	457.1	461.8	466.6	471.4	476.2	481.1	485.9
25	490.8	495.7	500.7	505.7	510.7	515.7	520.7	525.8
26	530.9	536.0	541.1	546.3	551.5	556.7	562.0	567.2
27	572.5	577.8	583.2	588.5	593.9	599.3	604.8	610.2
28	615.7	621.2	626.7	632.3	637.9	643.5	649.1	654.8
29	660.5	666.2	671.9	677.7	683.4	689.2	695.1	700.9
30	706.8	712.7	718.6	724.6	730.6	736.6	742.6	748.6
31	754.8	760 9	767.0	773.1	779.3	785.5	791.7	798.0
32	804.3	810 6	816.9	823.2	829.6	836.0	842.4	848.8
33	855.3	861.8	868 3	874 9	881.4	888.0	894.6	901.3
34	907.9	914.7	921.3	928.1	934.8	941.6	948.4	955.3
35	962.1	969 0	975 9	982.8	989 8	996 8	1003.8	1010.8
36	1017.9	1025 0	1032 1	1039.2	1046.3	1053.5	1060.7	1068.0
37	1075.2	1082.5	1089 8	1097.1	1104.5	1111.8	1119.2	1126.7
38	1134.1	1141.6	1149 1	1156.6	1164.2	1171 7	1179.3	1186.9
39	1194.6	1202.3	1210.0	1217.7	1225.4	1233.2	1241 0	1248 8
40	1256.6	1264.5	1272.4	1280.3	1288.2	1296.2	1304.2	1312 2
41	1320.3	1328.3	1336.4	1344.5	1352.7	1360.8	1369.0	1377.2
42	1385.4	1393.7	1402.0	1410.3	1418.6	1427.0	1435 4	1443.8
43	1452 2	1460.7	1469.1	1477.6	1486 2	1494.7	1503.3	1511.9
44	1520.5	1529.2	1537.9	1546.6	1555.3	1564.0	1572.8	1581.6
45	1590.4	1599 3	1608.2	1617.0	1626.0	1634.9	1643.9	1652.9

SURVEYING MEASURE (LINEAL).

Inches.	Links.	Feet.	Yards.	Chains.	Mile.	Fr. Metres.
1. =	.126 =	.0833 =	.0278 =	.00126 =	.0000158 =	.0254
7.92	1.	.66	.22	.01	.000125	.2012
12.	1.515	1.	.333	.01515	.000189	.3048
36.	4.545	3.	1.	.04545	.000568	.9144
792.	100.	66.	22.	1.	.0125	20.116
63360.	8000.	5280.	1760.	80.	1.	1609.315

One knot or geographical mile = 6086.07 feet = 1855.11 metres = 1.1526 statute mile.

One admiralty knot = 1.1515 statute miles = 6080 feet.

LONG MEASURE.

Inches.	Feet.	Yards.	Fath.	Poles.	Furl.	Mile.	Fr. Metres.
1. =	.083 =	.02778 =	.0139 =	.005 =	.000126 =	.0000158 =	.0254
12.	1.	.333	.1667	.0606	.00151	.0001894	.3048
36.	3.	1.	.5	.182	.00454	.000568	.9144
72.	6.	2.	1.	.364	.0091	.001136	1.8287
198.	16½.	5½.	2¾.	1.	.025	.003125	5.0291
7920.	660.	220.	110.	40.	1.	.125	201.16
63360.	5280.	1760.	880.	320.	8.	1.	1609.315

A palm = 3 inches.

A span = 9 inches.

A hand = 4 inches.

A cable's length = 120 fathoms.

FRENCH LONG MEASURE.

	Inches.	Feet.	Yards.	Miles.
Millimetre.....	.039368	.00328		
Centimetre	.39368	.03280		
Decimetre.....	3.9368	.32807	.109357	
Metre	39.368	3.2807	1.09357	
Decametre.....	393.68	32.807	10.9357	
Hectometre.....		328.07	109.357	.0621346
Kilometre		3280.7	1093.57	.6213466
Myriametre.....		32807.	10935.7	6.213466

SQUARE MEASURE.

Inches.	Feet.	Yards.	Perches.	Roods.	Acre.	Sq. Metres.
1.	= .00694	= .000772	= .0000255	= .00000064	= .000000159	= .000645
144.	1.	.111	.00367	.0000918	.000023	.0929
1296.	9.	1.	.0331	.000826	.0002066	.8361
39204.	272¼.	30¼.	1.	.025	.00625	25.292
1568160.	10890.	1210.	40.	1.	.25	1011.7
6272640.	43560.	4840.	160.	4.	1.	4046.7

100 square feet = 1 square.

10 square chains = 1 acre.

1 chain wide = 8 acres per mile.

1 hectare = 2.471143 acres.

1 square mile { = 27878400 square feet. = 3097600 square yards. = 640 acres.

Acres × .0015625 = square miles.

Square yard × .000000323 = square miles.

Acres × 4840 = square yards.

Square yards × .0002066 = acres.

A section of land is 1 mile square, and contains 640 acres.

A square acre is 208.71 ft. at each side; or 220 × 198 ft.

A square ½-acre is 147.58 ft. at each side; or 110 × 198 ft.

A square ¼-acre is 104.355 ft. at each side; or 55 × 198 ft.

A circular acre is 235.504 feet in diameter.

A circular ½ acre is 166.527 feet in diameter.

A circular ¼ acre is 117.752 feet in diameter.

FRENCH SQUARE MEASURE.

Square.	Square Inches.	Square Feet.	Square Yards	Acres.
Millimetre....	.00154	.0000107	.000001	
Centimetre...	.15498	.0010763	.000119	
Decimetre....	15.498	.1076305	.011958	
Metre or Cen	1549.8	10.76305	1.19589	.000247
Decametre...	154988.	1076.305	119.589	.024709
Hectare.....		107630.58	11958.95	2.47086
Kilometre.....	.38607 □ mls.	10763058.	1195895.	247.086
Myriametre...	38.607 "			24708.6

CUBIC MEASURE.

Inches.	Feet.	Yard.	Cubic Metres.
1. =	.0005788 =	.000002144 =	.000016386
1728.	1.	.03704	.028315
46656.	27.	1.	.764513

A cord of wood = 128 cubic feet, being four feet high, four feet wide, and eight feet long.

Forty-two cubic feet = a ton of shipping.

A perch of masonry contains 24¾ cubic feet.

A CUBIC FOOT IS EQUAL TO

1728 cubic inches.
.037037 cubic yard.
.803564 U. S. struck bushel of 2150.42 cubic inches.
3.21426 U. S. pecks.
7.48052 U. S. liquid galls. of 231 cubic inches.
6.42851 U. S. dry galls.
29.92208 U. S. liquid quarts.
25.71405 U. S. dry quarts.
59.84416 U. S. liquid pints.
51.42809 U. S. dry pints.
239.37662 U. S. gills.
.26667 flour barrel of 3 struck bus.
.23748 U. S. liquid barrel of 31½ galls.

FRENCH CUBIC OR SOLID MEASURE.

	Gill.	Pint.	Quart.	Gallon.	Peck.	Bushel	Cubic Inches.	Cubic Feet.
Centilitre.....Dry	.....	.0181	.....	.....	.....	.....	.61016	.....
Liquid	.0845	.0211	.....	.....	.....	.....		
Decilitre.....Dry	.....	.1816	.0908	.....	.0113	.....	6.1016	.....
Liquid	.8452	.2113	.1056	.0264	.....	.....		
Litre.....Dry	.....	1.816	.908	.....	.1135	.....	61.016	.0353
Liquid	8.452	2.113	1.056	.2641	.....	.....		
Decalitre.....Dry	.....	.....	9.08	.....	1.135	.2837	610.16	.3531
Liquid	84.52	21.13	10.56	2.641	.....	.....		
Hectolitre.....Dry	.....	.....	90.8	.....	11.35	2.837	6101.6	3.531
Liquid	.....	211.3	105.6	26.41	.....	.....		
Kilolitre or Cubic Metre.....Dry	.....	.....	.....	.....	113.5	28.37	61016.	35.31
Liquid	.....	.....	1056.5	264.1	.....	.....		
Myriolitre.....Dry	.....	.....	.....	.....	1135.	283.7	.....	353.1
Liquid	.....	.....	10565.	2641.4	.....	.....		

AVOIRDUPOIS WEIGHT.

The standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water, weighed in the air, at 39.83 degrees Fahr., barometer at thirty inches.

27.343 grains = 1 drachm.

Drachms.	Ounces.	Lbs.	Qrs.	Cwts.	Ton.	French Grammes.
1. =	.0625 =	.0039 =	.000139 =	.000035 =	.00000174 =	1.771846
16.	1.	.0625	.00223	.000558	.000028	28.34954
256.	16.	1.	.0357	.00893	.000447	453.59
7168.	448.	28.	1.	.25	.0125	12700.
28672.	1792.	112.	4.	1.	.05	50802.
573440.	35840.	2240.	80.	20.	1.	1016048.

A stone = 14 pounds.

A quintal = 100 pounds.

7000 grains = one avoirdupois pound = 1.21528 troy pounds.

5760 grains = one troy pound = .82285 avoirdupois pounds.

FRENCH WEIGHTS.

EQUIVALENT TO AVOIRDUPOIS.

	Grains.	Ounces.	Lbs.	Tons. 2240 lbs.
Milligramme.....	.015433			
Centigramme.....	.154331	.000352	.000022	
Decigramme.....	1.54331	.003527	.000220	
Gramme.....	15.4331	.035275	.002204	
Decagramme.....	154.331	.352758	.022047	
Hectogramme....	1543.31	3.52758	.220473	.000098
Kilogramme.....	15433.1	35.2758	2.20473	.000984
Myriogramme ...		352.758	22.0473	.009842
Quintal.....		3527.58	220.473	.098425
Millier or Tonne.		35275.8	2204.73	.984258

NOTE ON BRICK ARCHES.

FOR FLOORS.

The approximate number of bricks and the cost of brick-work in arches for floors, will depend somewhat upon the size and cost per M. of bricks.

With bricks $8\frac{1}{4} \times 4 \times 2$, and joints of mortar from $\frac{1}{8}$ to $\frac{1}{4}$ inch between them, edge-wise arches will require about 8 bricks per square foot of floor, and end-wise arches will require $16\frac{1}{2}$.

Estimating the average cost of hard brick at $10 per M., and the cost of laying, including mortar, centres, scaffolding, &c., at $10 per M. more, or $20 per M. in place, the edge-wise arches will cost **16** cents per square foot, and the end-wise arches **33** cents per square foot, put up complete.

STANDARD SIZES OF CAST SEPARATORS FOR BEAMS.

Size of Beam.		Distance C to C.		Weight in lbs.		Size of Bolt.	
		Beams.	Bolts.	Separator	2 Bolts.	Diameter.	Length.
6″	40 lbs.	3 in.	3 in.	5	1½	⅝	4⅛
7	55 "	4	3	7	1¾	⅝	5¼
8	65 "	4	4	8	1¾	⅝	5¼
9	70 "	5	4½	9	2¾	¾	6⅜
9	84 "	5	4½	9	2¾	¾	6⅜
9	150 "	6	4½	9	3¼	¾	7⅝
10½	105 "	5½	5½	11	3	¾	7
12	125 "	5½	6½	15	3	¾	7
12	170 "	6	6½	15	3¼	¾	7⅝
15	150 "	5½	9	17	3	¾	7
15	200 "	6	9	19	3¼	¾	7⅝

SOME OF THE PROPERTIES OF IRON.

The breaking strength of double-refined, or "best" "best" Phœnix rolled iron should run from 55,000 @ 60,000 pounds per square inch. A bar one foot long and one inch square should elongate 15 per cent. before breaking. It should not *set* under a strain less than 25,000 pounds per square inch. The proof strain is 20,000 pounds per square inch. A round bar of one inch diameter should bend nearly double when cold without any signs of fracture; but a square bar of same quality will show cracks at the corners, when bent at a much less angle than the round bar. The reduction of area under a breaking pull, should average about 25 per cent. on original section.

KIRKALDY'S CONCLUSIONS.—Mr. Kirkaldy sums up the results of his experimental inquiry in the following concluding observations, which the student should study carefully:

1. The breaking strain does *not* indicate the quality, as hitherto assumed.

2. A *high* breaking strain may be due to the iron being of superior quality, dense, fine, and moderately soft, or simply to its being very hard and unyielding.

3. A *low* breaking strain may be due to looseness and coarseness in the texture, or to extreme softness, although very close and fine in quality.

4. The contraction of area at fracture, previously overlooked, forms an essential element in estimating the quality of specimens.

5. The respective merits of various specimens can be correctly ascertained by comparing the breaking strain *jointly* with the contraction of area.

6. Inferior qualities show a much greater variation in the breaking strain than superior.

7. Greater differences exist between small and large bars in coarse than in fine varieties.

8. The prevailing opinion of a rough bar being stronger than a turned one is erroneous.

9. Rolled bars are slightly hardened by being forged down.

10. The breaking strain and contraction of area of iron plates are greater in the direction in which they are rolled than in a transverse direction.

22. Iron is less liable to snap the more it is worked and rolled.

33. The ratio of ultimate elongation may be greater in short than in long bars in some descriptions of iron, whilst in others the ratio is not affected by difference in the length.

44. Iron, like steel, is softened, and the breaking strain reduced, by being heated and allowed to cool slowly.

54. A great variation exists in the strength of iron bars which have been cut and welded; whilst some bear almost as much as the uncut bar, the strength of others is reduced fully a third.

55. The welding of steel bars, owing to their being so easily burned by slightly over-heating, is a difficult and uncertain operation.

56. Iron is injured by being brought to a white or welding heat, if not at the same time hammered or rolled.

57. The breaking strain is considerably less when the strain is applied suddenly instead of gradually, though some have imagined that the reverse is the case.

61. The specific gravity is found generally to indicate pretty correctly the quality of specimens.

62. *The density of iron is *decreased* by the process of wire-drawing, and by the similar process of cold rolling, instead of *increased*, as previously imagined.

64. The density of iron is decreased by being drawn out under a tensile strain, instead of increased, as believed by some.

*NOTE.—The conclusion of Mr. Kirkaldy in respect to cold rolling is undoubtedly true when the rolling amounts to wire-drawing; but when the compression of the surface by rolling diminishes the sectional area in greater proportion than it extends the bar, the result, according to the experience of the Pittsburgh Manufacturers, is a slight increase in the density of the iron.

200. It must be abundantly evident from the facts which have been produced that the *breaking strain* when taken alone gives a false impression of, instead of indicating the real quality of the iron, as the experiments which have been instituted reveal the somewhat *startling* fact that frequently the inferior kinds of iron actually yield a higher result than the superior. The *reason* of this difference was shown to be due to the fact, that whilst the one quality retained its original area only very slightly decreased by the strain, the *other* was reduced to less than one-half. Now surely this variation, hitherto unaccountably *completely overlooked*, is of importance as indicating the relative hardness or softness of the material, and thus, it is submitted, forms an essential element in considering the *safe load* that can be practically applied in various structures. *It must be borne in mind* that although the softness of the material has the effect of lessening the amount of the breaking strain, it has the very opposite effect as regards the *working strain*. This holds good for two reasons: first, the softer the iron the less liable it is to snap; and second, fine or soft iron being more uniform in quality can be more *depended upon in practice*. Hence the load which this description of iron can suspend with safety may approach much more nearly the limit of its breaking strain than can be attempted with the harder or coarser sorts, where a greater margin must necessarily be left.

202. As a necessary corollary to what we have just endeavored to establish, the writer now submits, in addition, that the *working* strain should be in proportion to the breaking strain per square inch of *fractured area*, and not to the breaking strain per square inch of *original area* as heretofore. Some kinds of iron experimented on by the writer, will sustain with safety more than double the load that others can suspend, especially in circumstances where the load is unsteady, and the structure exposed to concussions as in a ship or railway bridge.

Kirkaldy's rule for comparing the qualities of iron:

The breaking weight per square inch of the fractured area, instead of the breaking weight or strain per square inch of the original area.

MODULUS OF ELASTICITY is the *weight* that would extend an inch bar through a space equal to its length, supposing the elasticity perfect; and still further, the height of a column of the given material in *feet*, which will extend a bar of any length through a space equal to its length, is called the modulus of elasticity for the given material in feet. Thus, since one ton extends an inch bar of wrought iron one ten-thousandth of its length, it is evident at the same rate, 10,000 tons would extend it through its whole length, and 10,000 tons, or 22,400,000 pounds, is the modulus of elasticity of wrought iron, on this assumption. But an inch bar of iron to weigh 22,400,000 pounds, at $3\frac{1}{3}$ pounds per foot, would be 6,787,878 feet in length, which is the modulus of elasticity in feet. The modulus varies according to the character of the iron submitted to test, being much greater in the better qualities than in the inferior.

Given the length of a trial bar: its sectional area in inches and its stretch under a fixed load per square inch to find its modulus of elasticity.

Example: From table on page 49, take $3'' \times \frac{7}{8}''$ bar $\times$ 35′. Length in feet, 35′; length in inches 420″; stretch, .2587″ under a load of 20,000 pounds per square inch of section.

Then $\frac{420''}{.2587''} = 1623\frac{1}{2}$, amount of stretch in terms of the length, and $1623\frac{1}{2} \times 20{,}000$ lbs. = 32,470,000 modulus of elasticity.

Although with wrought iron the *compression* is nearly as the weight applied, up to 12 or 15 tons, this is not the case with cast iron: *i. e., the ratio of the weight* to the *compression is not constant*, the compression becoming more per ton as the weight increases. Thus, a cast iron bar, one square inch in section, was compressed $\frac{1}{5000}$ of its length by *one ton* of direct pressure, but with 17 tons instead of being compressed $\frac{17}{5000}$ it was compressed $\frac{20}{5000}$.

The extension of iron for all practical purposes, is as follows:

Wrought iron, $\frac{1}{10000}$ of its length per ton per square inch.

Cast iron, $\frac{1}{5000}$ of its length per ton per square inch.

The contraction of a wrought iron rod in cooling is about equivalent to $\frac{1}{10000}$ of its length from a decrease of 15° Fahr., and the strain thus induced is about *one ton* for every square inch of sectional area in the bar.

For a rod of the lengths given below the contraction will be as follows:

Length of rod in feet,	10	20	30	40	50	75	100	150
Contrac'n in inches for 15°	.012	.024	.036	.048	.060	.090	.120	.180
" " 150°	.120	.240	.360	.480	.600	.900	1.200	1.800
" " 100°	.080	.160	.240	.320	.400	.600	.800	1.200

Contraction and expansion being equal, the pressure per square inch induced by heating or cooling is as follows:

For temperatures varying by 15° Fahr.:

Variation,	15	30	45	60	75	105	120	150	degrees.
Pressure,	1	2	3	4	5	7	8	10	tons.

Stoney gives 8° C = 14.4 Fahr. as equivalent to a pressure of one ton per square inch for wrought iron, and 15° C = 27 Fahr. for cast iron.

DIMINUTION OF TENACITY OF WROUGHT IRON AT HIGH TEMPERATURES.

Experiments Franklin Inst., 1839. Walter Johnson & Benj. Reeves, Com.

C.	Fahr.	Diminution p. ct. of max. tenacity.	C.	Fahr.	Diminution p. ct. of max. tenacity.
271°	520°	0.0738	500°	932°	0.3324
299		0.0869	508		0.3593
313		0.0899	554		0.4478
316		0.0964	599		0.5514
332	630	0.1047	624	1154	0.6000
350		0.1155	626		0.6011
378		0.1436	642		0.6352
389	732	0.1491	669		0.6622
390		0.1535	674	1245	0.6715
408		0.1589	708	1306	0.7001
410		0.1627			
440		0.2010			

LINEAR EXPANSION OF METALS.

	Between 0° and 100° C.	For 1° C.	For 1° Fahr.
Zinc,	0.00294		
Lead,	0.00284		
Tin,	0.00222		
Copper, yellow,	0.00188		
" red,	0.00171		
* Forged Iron,	0.00122	.0000122	.00000677
† Steel,	0.00114	.0000114	.00000633
* Cast Iron,	0.00111	.0000111	.00000616

For a change of 100° Fahr. a bar of iron 1475′ long will extend 1 foot. Similarly, a bar 100 feet long will extend .0678 foot, or .8136 inch.

According to the experiments of Du Long & Petit, we have the mean expansion of iron, copper and platinum, between 0° and 100° C., and 0° and 300° C., as below :

	From 0° to 100° C.	0° to 300° C.
Iron,	0.00180	0.00146
Copper,	0.00171	0.00188
Platinum,	0.00884	0.00918

The law for the expansion of iron, steel and cast iron at very high temperatures, according to Rinman, is as follows :

	From 25° to 525° C. red heat=500° C.	For 1° C.	1° Fahr.
Iron,	.00714	.0000143	=.0000080
Steel,	.01071	.0000214	=.0000119
Cast Iron,	.01250	.0000250	=.0000139
	From 25° to 1300° nascent white=1275° C.		
Iron,	.01250	.00000981	=.00000545
Steel,	.01787	.00001400	=.00000777
Cast Iron,	.02144	.00001680	=.00000933
	From 500° to 1500° dull red to white heat=1000° C. difference.		
Iron,	.00535	.00000535	=.0000030
Steel,	.00714	.00000714	=.0000040
Cast Iron,	.00893	.00000893	=.0000050

Ratio of Expansion in Hundred parts, assuming Forge Iron to expand between 0° and 100° C. = .00122.

	From 0° to 100°	25° to 525°	25° to 1300°	500° to 1500°
Iron,	100 per ct.	117 per ct.	80 per ct.	44 per ct.
Steel,	93 "	175 "	114 "	58 "
Cast Iron,	91 "	205 "	137 "	73 "

* Laplace & Lavoisier. † Ramsden.

DIFFERENT COLORS OF IRON CAUSED BY HEAT.

POUILLET.

C.	FAHR.	COLOR.
210°	410°	Pale Yellow.
221	430	Dull Yellow.
256	493	Crimson.
261 to 370	502 to 680	Violet, Purple and Dull Blue; between 261° C. to 370° C. it passes to Bright Blue, to Sea Green, and then disappears.
500	932	Commences to be covered with a light coating of oxide; loses a good deal of its hardness, becomes a good deal more impressible to the hammer and can be twisted with ease.
525	977	Becomes Nascent Red.
700	1292	Sombre Red.
800	1472	Nascent Cherry.
900	1657	Cherry.
1000	1832	Bright Cherry.
1100	2012	Dull Orange.
1200	2192	Bright Orange.
1300	2372	White.
1400	2552	Brilliant White—welding heat.
1500 to 1600	2732 to 2912	Dazzling White.

MELTING POINT OF METALS.

NAME.	FAHR.	FAHR.	AUTHORITY.
Platina	4593°		
Antimony	955	842	J. Lowthian Bell.
Bismuth	487	507	"
Tin (average)	475		
Lead "	622	620	"
Zinc	772	782	"
Cast Iron	2786	1922..2012 White. 2012..2192 Grey.	Pouillet.
Wrought Iron	2552	2733	Welding heat. "
Copper (average)	2174		

SPECIFIC GRAVITY
AND
WEIGHTS OF VARIOUS SUBSTANCES.

Name of Substance.	WEIGHTS.			Specific Gravity.
	Per Cubic Foot.	Per □Foot. 1 in. thick.	Per Cubic Inch.	
Water, Pure	62.3	5.19	.036	1.000
Water, Sea	64.3	5.36	.037	1.028
Wrought Iron	480	40.00	.277	7.70
Cast Iron	450	37.50	.260	7.20
Steel	490	40.84	.283	7.84
Lead	710	59.16	.410	11.36
Copper, Rolled	548	45.66	.317	8.80
Brass, Rolled	524	43.66	.302	8.40
Sand	98	8.23	.057	1.57
Clay	120	10.00	.069	1.92
Brickwork, Common	120	10.00	.069	1.92
" Close Joints	140	11.66	.081	2.24
Limestone	168	18.00	.124	2.68
Glass	156	13.00	.090	2.49
Pine, White	30	2.50	.017	.48
Pine, Yellow	35	2.91	.019	.56
Hemlock	25	2.08	.015	.40
Maple	49	4.08	.028	.78
Oak, White	50	4.16	.030	.80
Walnut	41	3.41	.023	.65

Phœnix Wrought Iron Columns.

S. J. REEVES, Patentee.

CLAIM.—"The *uniting together* three or more pieces of wrought iron made with *flanges in the direction of their length* so that they shall form a column or shaft, to be used as posts and also as braces or compression chords, in the construction of buildings, bridges or other structures."

SUIT IN EQUITY.

Samuel J. Reeves *vs.* The Keystone Bridge Company et al., for infringement of complainant's wrought iron column patent.

In the United States Circuit Court, MCKENNAN, Judge:

OPINION OF THE COURT.

"The complainant is entitled to an allowance of the prayers of his bill, and a decree will be entered for a *perpetual injunction*, and an account with costs."

NOTICE.

The following and similar combinations, composed of three or more pieces of wrought iron *made with flanges* in the *direction of their length and united together* so as to form a column or shaft to be used as posts, braces or compression chords in bridges, &c., come under the protection of this patent, and can only be manufactured and sold by the Phœnix Iron Company, sole owners of the patent.

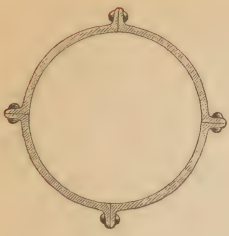
Any persons infringing said patent will be liable to prosecution for damages, according to law.

Figures 1, 2 and 3 exhibit the general and most approved form of Phœnix Wrought Iron Columns.

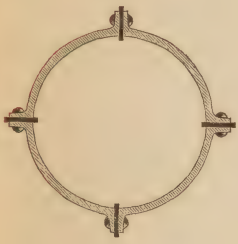
Fig. 5 is the same as Fig. 1, except in the mode of uniting the flanges.

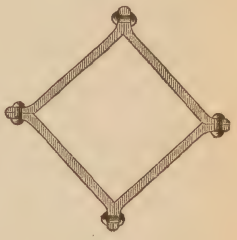
Fig. 7 is the same as Fig. 2, except that in the former the flanged pieces are curved inward and in the latter outward. Fig. 2 is much stronger than the other, as will appear conclusive by reference to Fig. 8, in which the two sections are contrasted. The greater the distance the material is placed from the axis of the column, the greater are its moments of resistance. The defect of Fig. 7 in this particular is obvious.

Increasing the diameter of a column at the middle, without at the same time increasing the quantity of metal in the section, adds nothing to its strength. On the contrary, in consequence of the pieces being bent out of a straight line, to accomplish the object, their power to resist an axial force is greatly diminished.

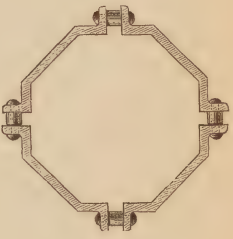

1.

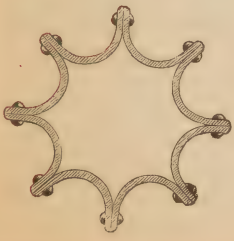

2.

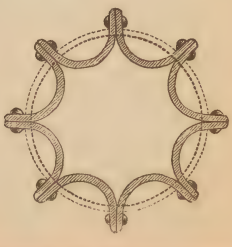

3.


4.


5.


6.


7.


8.

EXPERIMENTS ON HOLLOW TUBES, ten feet long and of different diameters and thicknesses, for ascertaining the form to resist a crushing strain, (see E. Clarke's work on The Brittania and Conway Tubular Bridges, pp. 322–362,) made by Prof. Hodgkinson:

"It will be observed that as regards form, other circumstances remaining constant, that a large square □ with thin plates, is the weakest form experimented upon, the next in order is the rectangle ▭, which is nearly doubled in its resistance to crippling by the addition of a division across the centre, thus, ▭▭; the square divided into four compartments ⊞ gave still better results, while the circular form ○ was *much the strongest of all.*

"If we compare together experiment 8, rectangular form, and experiment 7, cylindrical form, the importance of form is very evident, for we have, with the same length,

		Weight of Tube.	Breaking Weight.
p. 341.	Rectangular form ▭▭,	82 lbs.	43,673 lbs.
p. 343.	Cylindrical form ○,	59 "	47,212 "

$$\frac{43,673}{82} = 533; \quad \frac{47,212}{59} = 800.$$

Ratio, 2 to 3, or 1 to 1½."

THERMOMETERS.

To change degrees of Fahr. to degrees of Cent.: if above freezing point, from the degree of Fahr., subtract 32; multiply the remainder by 5; divide the product by 9. If below freezing point, first *add* 32; then multiply by 5 and divide by 9.

To change degrees of Cent. to degrees of Fahr.: if above freezing point, multiply by 9 and divide by 5, and add 32. If below freezing point, multiply by 9, divide by 5 and subtract 32. Or, double the degrees Cent.: deduct 10 per cent. and add 32, when above freezing point; when below freezing point, proceed as above and deduct from 32.

COAL PRODUCTION OF THE WORLD.

By James MacFarlane, Author of "The Coal Regions of America."

YEAR.	COUNTRIES.	TONS.
1872	United States	41,000,000
1872	Nova Scotia	880,950
1872	Great Britain	123,386,758
1872	France	15,000,000
1871	Belgium	13,773,176
1870	Austria	6,443,575
1870	Prussia	23,316,238
1862	Poland	112,500
1867	Russia	259,521
1869	Spain	593,033
1868	India	547,971
1869	New South Wales	919,522
	Total reports	226,233,244
	Chili, China, New Zealand, Pacific Coast, &c., &c., estimated	1,800,000
	Total of the World	228,033,244

Annual make of Iron and Steel in the World.

YEAR.	COUNTRIES.	TONS.
1872	Great Britain	6,741,929
1873	United States	2,695,000
1871	Germany	1,664,802
1873	France	1,381,000
1872	Belgium	652,565
1871	Austria, with Hungary	424,606
1871	Russia	354,000
1872	Sweden	322,000
1872	Luxembourg	300,000
	Canada	100,000
1872	Italy	73,709
1870	Spain	54,007
	Norway	20,000
	South America	15,000
1871	Japan	9,370
1872	Switzerland	7,500
	Asia	40,000
	Africa	20,000
	Australasia	10,000
	Total	14,885,488

BRITISH IRON PRODUCTION.

The statistics of the British iron trade from 1867 to 1873 have been admirably summarized by Messrs. William Fallows & Co., of Liverpool, and will be found below:

YEAR.	Production of pig iron in Great Britain.	Average price of Scotch pig iron.	Total stock, Dec. 31, in Scotland and North of England.	Total exports of Iron of all kinds.	
				Quantity.	Value.
	Tons.		Tons.	Tons.	£.
1867	4,761,023	52*s.* 6*d.*	644,345	1,968,025	15,050,391
1868	4,970,206	52*s.* 9*d.*	720,927	2,041,852	15,036,398
1869	5,445,757	53*s.* 3*d.*	735,607	2,675,331	19,519,201
1870	5,963,515	54*s.* 4*d.*	782,345	2,825,575	24,038,090
1871	6,627,179	59*s.* 0*d.*	558,331	3,169,219	26,124,134
1872	6,741,929	101*s.* 10*d.*	235,628	3,382,762	35,996,167
1873	6,850,000*	117*s.* 3*d.*	200,328	2,959,314	37,779,586

* Estimated.

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